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THE ILFORD MANUAL OF PHOTOGRAPHY

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FOREWORD

FOR over fifty years the ILFORD MANUAL OF PHOTOGRAPHY has been recognized as a standard work for photographers of all classes, and in this period nearly half a million copies have been sold.

From time to time new and revised editions have been issued to keep the MANUAL up to date as regards new developments, techniques, and applications. In the present instance the volume has been recast and almost completely rewritten to bring it into line with the best modern photographic practice. It is confidently believed that it represents a simple and straightforward account of photography as we know it to-day, from which it should be possible to obtain a thorough working knowledge of the subject.

In the compilation of this edition many members of the staff of Ilford Limited have assisted as contributors, advisers and critics, and the Editor desires to express his most grateful thanks to all of them, and particularly to Mr. George Dorman for his untiring efforts in reading, correcting, and arranging the presentation and lay-out of the book.

The Editor would also like to take this opportunity of acknowledging the excellent matter provided by Mr. F. J. Pittock, F.R.P.S., University College, London, in the chapter on photo-micrography.

JAMES MITCHELL

ILFORD, *September* 1942

CONTENTS

CHAPTER I

THE MECHANISM OF IMAGE FORMATION

●

Light radiated from the sun travels through space and impinges upon the crowded surface of our world. According to the way in which it is received or rejected, in whole or in part, a complex pattern of light, shade and colour originates, which appearing in the visual field is interpreted by us from past experience in terms of three-dimensional solidity. The picture made by the camera is a more or less faithful representation of what a single eye might have seen, and from the patches of light and shade in the positive photographic print the eye and the mind working together can arrive at a reasonably accurate interpretation of the form and nature of the objects portrayed. Thus, light makes it possible for us to be well informed about the shapes, sizes, and textures of things we cannot touch.

The nature of light has been the subject of much speculation. In Newton's view it was corpuscular, but this theory could not be made to fit all the known facts, so the wave theory of Huyghens and Young took its place. Planck found that many facts could be explained only on the assumption that energy is always emitted in "packets" or quanta, and the corpuscular theory was reborn. Nowadays physicists make their interpretations in terms of both wave and quantum theories.

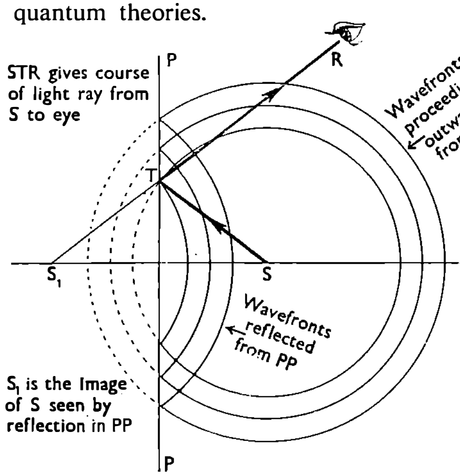


Fig. 1. Reflection of light waves by a plane surface.

For problems in photographic optics only simple wave theory need

be considered, in which light is taken to be a transverse electromagnetic wave motion in a hypothetical medium, the ether. A stone dropped into a pond of still water causes a train of waves to spread out in all directions on the surface of the water. These are *transverse* waves, because the particles of water are moved up and down as the wave passes across them. At any moment the advancing wave front is *circular* in form. Now such waves are almost completely confined to the surface of the water. A point source of light, however, emits energy in the form of waves which spread out in all directions, and hence the wave fronts form *spherical surfaces* of ever-increasing size. These wave fronts may be deviated from their original directions by obstacles situated in their paths, the deviations being of different kinds according to the shape and nature of the obstacle. For convenience we postulate the existence of light rays represented by straight lines with directions perpendicular to the wave fronts, and by means of which change of direction of travel of a wave front can be shown easily.

In Fig. 2 the distance from wave crest to wave crest is defined as the wavelength—denoted by the Greek letter λ (lambda)—and this distance is constant for light of any given colour.

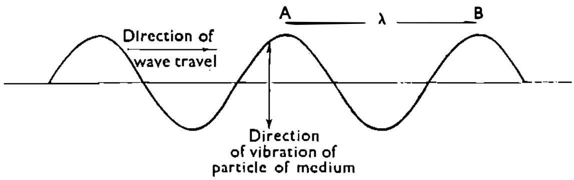


Fig. 2. Illustrating the propagation of a simple wave.

White light is a mixture of all the spectrum colours—violet, blue, green, yellow, orange, and red—and for all these the velocity of propagation in vacuum is constant. The wavelength, *i.e.*, the distance from crest to crest, varies, however, according to the colour, being shortest for the violet rays and becoming progressively longer towards the red end of the spectrum.

Velocity and wavelength are related by the equation $V = n\lambda$ where n is the frequency of vibration or the number of waves passing any given point per second.

Colour	Wavelength in Ångström Units
Violet	4,000–4,600
Blue	4,600–5,100
Green	5,100–5,800
Yellow	5,800–6,000
Orange	6,000–6,300
Red	6,300–7,500

1 Ångström unit (Å) $= 10^{-8}$ cm.*

* 10^{-8} cm. is equal to one hundred millionth part of a centimetre.

Visible light occupies only a minute part of the total range of electromagnetic radiation, but photographic emulsions can be made to respond to quite an extensive range, as shown in Fig. 3. When light passes through transparent matter its velocity depends upon the nature of this matter, and in general when it passes from one transparent medium to another its velocity changes. When the

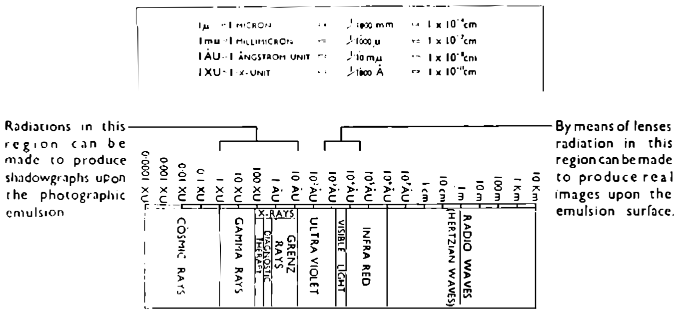


Fig. 3. Range of electromagnetic waves.

wave front reaches the surface of the second medium obliquely, the change of velocity is accompanied by a change in direction of the wavefront. This results in a bending of the "rays" of light, which is known as refraction, and it is upon this fact that the formation of images depends.

If V is the velocity in vacuum and V' the velocity through the material for a given wavelength of light, then V/V' is a constant for the material, and is known as the *true refractive index* of the material for that particular wavelength. Refractive index varies with wavelength, being in general greater for the blue than the red. For most purposes the refractive index may be taken as being equal to V''/V' where V'' is the velocity of light in air.

From our point of view the bending which occurs when light rays pass from air into glass and out again into air is of particular interest, as also are the refractive indices of the various types of glass used in the manufacture of photographic lenses. Some figures for these are given herewith:—

Glass	Refractive Index
Crown	1·46–1·53
Flint	1·53–1·65
Dense flint	1·65–1·92

The change in direction which occurs when light rays passing through air impinge obliquely on a glass surface is given by the

following equation:

$$\frac{\sin i}{\sin r} = \mu$$

where μ is the refractive index of the glass and i and r are the angles of incidence and refraction respectively. *Sin i* is given by the ratio AB/BO and *sin r* by CD/DO. BOD represents the path of the ray.

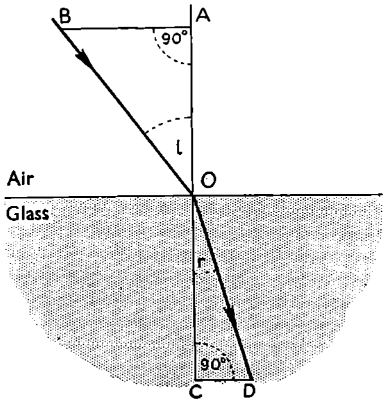


Fig. 4. Light ray passing obliquely from air to glass.

It follows that by placing in the path of the light masses of glass having suitably shaped surfaces the direction of travel of light may be altered at will. In passing through a prism of the type illustrated

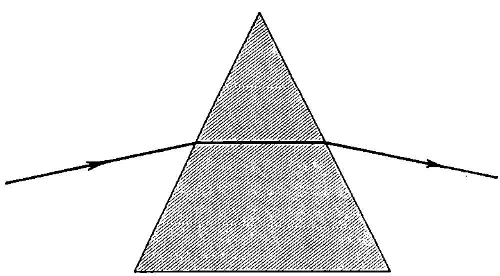


Fig. 5. Refraction of light caused by passage through a prism.

in Fig. 5, the course of a ray of light is twice altered, the amount of change depending on the refracting angle of the prism and on the refractive index of the glass. The refracting angle is the angle between the two faces through which the ray of light passes.

We know already that the refractive index varies for different coloured lights, so that if white light passes through the prism it leaves it as a band of coloured lights. In other words, radiations of

different wavelengths are deviated to different extents and a spectrum is produced (see Fig. 6). By placing two suitable prisms of different kinds of glass together, but with their refractive angles turned in opposite directions, it is possible to neutralize the dispersion, *i.e.*, the separation of the coloured rays, while retaining a considerable degree of deviation. This is an important fact, for upon it depends the production of lenses which can bring differently coloured rays to a common focus.

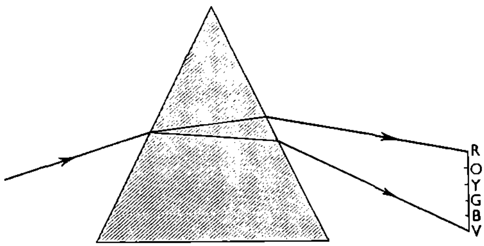


Fig. 6. Dispersion—the formation of a spectrum by means of a prism.

The Action of a Lens. A simple lens may be considered to be formed from an infinite number of prisms, as shown in section in Fig. 7.

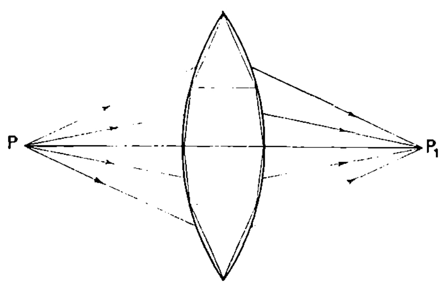


Fig. 7. The lens as a series of prisms. The lens illustrated is biconvex. Such a lens can form a real image which may be projected upon a screen.

Light spreading out from a point source P, and reaching the surface of the lens, is redirected according to the angle between the ray and the glass surface, and provided that the conditions are right the redirected rays can be brought together once more to form an image at a point P_1. As we have seen, the refractive index, and therefore the amount of bending, varies for *different* colours, so that if the point source is radiating white light, a series of coloured images will be produced at *different* distances from the lens—blue being nearest and red furthest away. This effect is known as

chromatic aberration. It can be corrected and the various coloured images made to coincide by constructing lenses from more than one component, using glasses of different compositions.

The lens illustrated in Fig. 7 has two convex surfaces, but lenses may be, and often are, constructed with two concave surfaces, one concave and one convex, or with one plane surface.

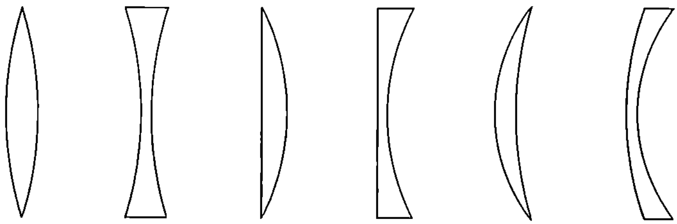


Fig. 8.

Double convex. Double concave. Plano-convex. Plano-concave. Convergent meniscus. Divergent meniscus.

The use of aspherical surfaces has also been considered, but so far no commercial photographic objectives having such surfaces have been made available. Only the cheapest camera lenses are single—most objectives are complex, and consist of a number of component parts which may be in contact or separated by some distance.

Lenses are known as positive or negative, according to whether they can form real or only virtual images. The image produced by the lens illustrated in Fig. 7 is real, because it can be projected upon a screen, but the image formed by a lens of the type shown in Fig. 9 cannot be projected in this way. It is a virtual image similar in nature to the reflected image obtained with a flat mirror. Negative lenses are used as component parts of photographic objectives, but the overall effect must always be that of a positive lens, since a real image is required. A complex camera lens is essentially similar to a simple positive lens in its image-forming properties.

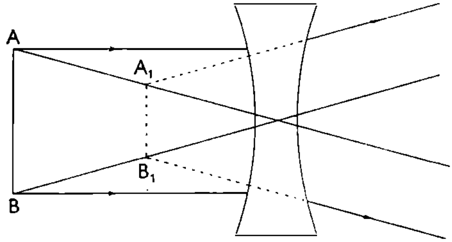


Fig. 9. Formation of a virtual image by means of a biconcave lens. Such a lens produces an image which is erect and diminished.

Image Formation. Let us consider the matter a little more closely. In Fig. 10 rays of light *R R* and *S S*, coming from a particular point in a distant object fall on the lens, and are bent in opposite directions according as they meet the lens above or below its centre, with the result that they meet at the point *O*. Thus, they, with other rays from the same origin, form an image of this point. The same thing occurs with the sets of rays proceeding from every other point in the object, with the result that an image of the *object* is formed on a screen placed behind the lens. Rays (shown as dotted lines) which fall obliquely on the lens, *e.g.*, from a point situated *above* the centre *A B* of the lens, obviously come to a focus *below A B*, and *vice versa*. Hence the image is upside down.

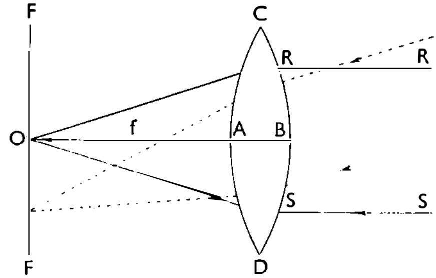


Fig. 10. Image formation by a single lens.

Focal Length. In the case of a flat object, and with a perfect lens, all these points or foci of light would be formed on a flat surface *FF* at right-angles to the ray of light passing perpendicularly and without deviation through the centre of the lens. When the rays falling on the lens come from a very distant object, and therefore travel along parallel paths towards the lens, the distance of the image from the lens is the *focal length* of the lens, often denoted by the symbol *f*. If the lens is turned round a second focus is obtained, but the focal length is the same whichever way the lens faces. The term "focus" is so often used in common speech and in catalogues, in the sense of "focal length," that it may almost be said to have acquired the meaning of length as well as of meeting-place.

The definition of focal length given above as the distance between the image and the lens requires amplification, particularly where compound lenses are concerned, when it is necessary to take the measurement from a point within the lens.

Principal Points. As shown by Gauss, the bending of light which takes place at the two glass-air surfaces of a lens may, for the purpose of calculation, be assumed to take place at one of two equivalent refracting surfaces.

The points at which the optic axis of the lens cuts these two surfaces are known as the Principal or Gaussian points.

Nodal Points. The ray which passes through the centre of a thin lens is undeviated. Thick lenses also have an optic centre which must be on the optic axis, but which may be inside or outside the lens itself. Any ray which passes through this point leaves the lens in the same direction as that in which it entered (cf. Fig. 11), but with a displacement along the direction of the optic axis. The interrupted path of this ray forms a *secondary axis*.

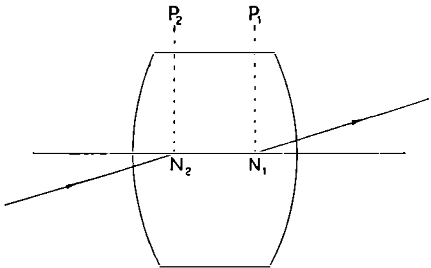


Fig. 11. Nodal points.

The intersections of the incident and emergent parts of the ray with the optic axis constitute the *nodal points*, and the planes through these points at right-angles to the axis are called the *nodal planes*. Where the same medium, for example air, is to be found on both sides of the lens, the nodal points are identical with the Principal (or Gaussian) points already described.

Equations Governing Image Formation. The making of negatives in the camera, enlarging and projecting, are all essentially similar operations in which only the relative distances of the object and image from the lens vary. The facts of image formation apply to all, and the fundamental relationships may be derived as follows:—

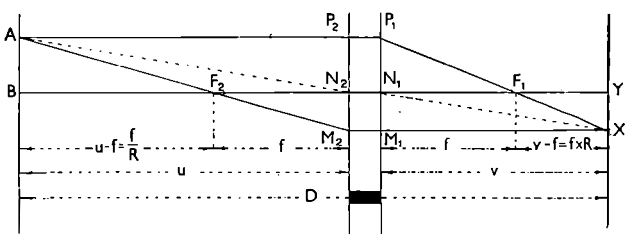


Fig. 12. Geometry of image formation.

In the diagram P_1M_1 and P_2M_2 represent the nodal planes and N_1 and N_2 the nodal points.

The object $A\,B$ is distant u from the plane through N_2, and the image $X\,Y$ is distant v from the plane through N_1. $A\,P_2\,P_1$ is the ray from A entering the lens in a direction parallel to the optic axis. After refraction it passes through the focal point F_1. $A\,M_2$ is the ray from A passing through the focal point F_2. The dotted lines

$A\,N_2$ and $N_1\,X$ represent the course of the undeviated ray from A. It can easily be shown that triangles $A\,P_2\,N_2$ and $X\,M_1\,N_1$ are similar, and

$$\frac{v}{u} = \frac{X\,Y}{A\,B} = \frac{\text{size of image}}{\text{size of object}}$$

$$\textit{i.e.}, \text{ magnification } (R) = \frac{v}{u} \quad . \quad . \quad . \quad (1)$$

From the figure also

$$B\,F_2 = u - f$$

$$Y\,F_1 = v - f$$

$$\frac{B\,F_2}{f} = \frac{A\,B}{M_2 N_2} = \frac{A\,B}{X\,Y} = \frac{u}{v}$$

$$\textit{i.e.}, \frac{u-f}{f} = \frac{u}{v} = \frac{1}{R} \quad . \quad . \quad (2)$$

$$\text{and similarly} \frac{v-f}{f} = \frac{v}{u} = R \quad . \quad . \quad . \quad . \quad (3)$$

$$\text{From (2) } u - f = \frac{uf}{v}$$

Dividing by uf we get

$$\frac{1}{f} - \frac{1}{u} = \frac{1}{v}$$

$$\text{or } \frac{1}{u} + \frac{1}{v} = \frac{1}{f} \quad . \quad . \quad . \quad . \quad (4)$$

Focal Length and Perspective. The points of intersection on a plane at right-angles to the direction of vision of lines drawn from the view-point to all points of the object constitute a point-by-point perspective representation of the object, as seen from that particular view-point, and the images obtained on the camera viewing screen and on the exposed negative are similarly correct representations of the appearance of the subject as viewed from the position of the camera lens, provided that they too are viewed from the correct view-point. This means that contact prints should be viewed from a distance equal to that which separated lens and negative material when the camera exposure was made. If this condition were to be complied with, it would mean that most contact prints would have to be examined at less than five inches from the eyes. Since ten inches is usually considered to be the minimum comfortable viewing distance, the best practice is to make enlargements having a magnification equal to ten/lens-plate distance.* Such enlargements viewed at ten inches will again correctly represent the object as seen from the position of the camera lens. We must remember that the correctness of the perspective is no guarantee that the picture will be pleasing.

*The distance should be taken from the back principal plane of the lens and in general it will be nearly equal to the focal length.

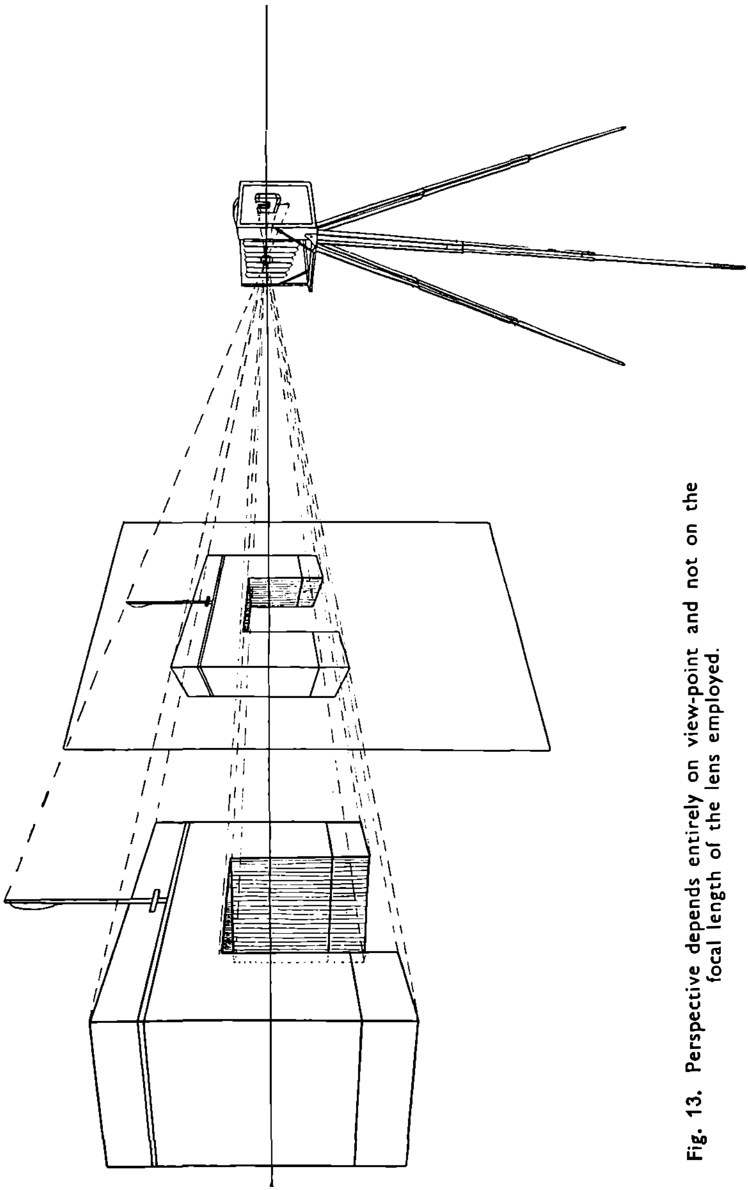


Fig. 13. Perspective depends entirely on view-point and not on the focal length of the lens employed.

If two objects of the same size, standing one behind the other, are separated by a distance x, the distance of the nearer object from the view-point being nx, the relative sizes of the images will be $n/n + 1$.

Thus, if $n = 2$ one will be reproduced as two-thirds the size of the other. If n is 9 the ratio will be 9/10. The portrait painter takes care to work at a considerable distance from his subject to ensure that size relationship of objects in different planes will be pleasing—in other words, to avoid too steep a perspective. The photographer is bound by the same rules as the artist with much less power for "misrepresentation." He, too, must work well back from his sitter if he wishes to produce pleasing portraits, using a fairly long focus lens if he desires to get a large image. Stated briefly, the size of the image varies with the distance of the object and with the focal length of the lens, while the drawing or perspective of the image in the case of any solid object or natural scene depends solely on its distance from the camera. At a shorter distance the image will be larger, but the perspective steeper. On the other hand, the use of lenses of different focal lengths from the same view-point will produce photographs identical in perspective rendering and differing only as regards the size in which the object is reproduced.

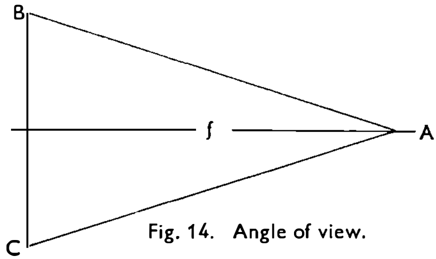


Fig. 14. Angle of view.

Focal Length and Angle of View. Considered in relation to the size of plate or film on which a lens is used, the focal length determines the angle of view and, therefore, the amount of subject included in the negative. The angle of view is the angle at A included between the lines $A\,B$ and $A\,C$, where f is the focal length of the lens and $B\,C$ the diagonal of the plate or film. An angle of 50°, equivalent to a $4\frac{1}{2}$-in. lens on a $3\frac{1}{2} \times 2\frac{1}{2}$-in. camera, may be said to be the normal, and is adopted by most makers in selecting lenses for hand-cameras. Lenses of longer focal length are not normally fitted to hand-cameras with the exception of reflexes, on account of bulk and uncertainty in focussing.

Wide angle lenses of special construction can be obtained embracing angles up to 90° and over. It will be understood that such lenses act as wide angle lenses only when used in conjunction with negatives of the necessary size. Any lens will function as a narrow angle lens simply by using it with a small enough plate or film.

The maximum angle over which a lens gives good definition and sufficient uniform illumination is known as its angle of covering power.

With miniature cameras using 35 mm. film negative size 36 mm. × 24 mm. ($1\frac{1}{2}$ in. × 1 in.), the 50-mm. (2-in.) lenses fitted as standard provide an angle of view of about 45°. The very wide angle lenses available embrace approximately 75° and have, therefore, focal lengths of the order of $1\frac{1}{8}$ in., while lenses giving angles of 60° to 65° are also available and are sufficiently wide angle to be useful in confined spaces.

Table of View Angles. The following table enables the angle of view corresponding with a given focal length and size of negative to be calculated.

To use the table the diagonal of the plate or film is divided by the equivalent focal length of the lens.

Quotient	Angle	Quotient	Angle
0·35	20°	1·27	65°
0·44	25	1·40	70
0·54	30	1·53	75
0·63	35	1·68	80
0·73	40	1·83	85
0·83	45	2·00	90
0·93	50	2·38	100
1·04	55	2·86	110
1·15	60	3·46	120

Covering Power and Rise of Front. It is often an advantage to know what amount of rise and fall from its central position is permissible when using a lens of known focal length and covering power; take, for example, a $4\frac{1}{2}$-in. lens covering 70° and used on a $3\frac{1}{2} \times 2\frac{1}{2}$-in. plate. It will be seen from the table of view angles that the diameter of field covered by a $4\frac{1}{2}$-in. lens at 70° is 6·3 in., then by drawing a circle of this diameter and placing centrally in it a rectangle of $3\frac{1}{2} \times 2\frac{1}{2}$ in., the actual measurement will show that in the "upright" position the rectangle can be moved a distance of over 1 in. either up or down without being taken out of the field. By a similar combination of calculations and plotting out, it is possible to calculate the angle of covering power required for a given amount of rise when using, say, a 7-in. lens with a 5 × 4-in. plate, or the focal length for, say, a 2-in. rise on a quarter-plate when using a lens of 70° covering power.

The Diaphragm. The light beam passing through a photographic objective is limited by means of a fixed or variable diaphragm known by analogy with the eye as the iris. The effective diameter of the diaphragm is the diameter of the beam of light incident upon

the lens and parallel to the axis which, after passing through the lens components in front of the diaphragm, completely fills the aperture. With single lenses, where the diaphragm is in front of the lens, the real diameter is the effective diameter. If the effective diameter is $\frac{1}{n}$th of the focal length the relative aperture of the diaphragm is given by the ratio f/n, which is usually defined as the f/No. The maximum aperture of a lens is the relative aperture of the largest diaphragm which can be used with it.

Losses of Light by Reflection and Absorption within Lens Systems. Because of losses due to absorption in the material of the lens and to reflection from the various glass-air surfaces a great deal of the light incident upon a lens is lost. (An average figure is 5 per cent. for each glass-air surface.) Some of the reflected light is re-reflected from other surfaces and may ultimately reach the film to cause flare or ghost. Means of reducing reflection by the use of thin films of fluorite deposited upon the lens surfaces have recently been discovered and are being applied in lens manufacture. The conditions to be satisfied are that the refractive index for the substance of the film must be equal to the square root of that of the glass, and that its optical thickness shall be one-quarter the wave-length of the incident light. It is thus clear that complete satisfaction of the conditions cannot be expected for the whole spectrum, but it is claimed in practice that very good results can be obtained.

Relative Apertures and Image Brightness. If it is assumed that two lenses of the same focal length show equal light losses by absorption and reflection within the lens system, then in the case of objects at a great distance from the camera forming images at the centre of the field, the image brightnesses will be proportional to the areas of the respective effective apertures. Where a lens of double the focal length, but of the same diameter, is concerned, the image will be increased four times in area, and the brightness thus reduced to one-fourth. Image brightness is thus inversely proportional to the square of the relative aperture.

***f*/Nos.** It follows from the above that the exposure necessary at $f/4$ is one-quarter that necessary at $f/8$, since $\frac{4^2}{8^2} = \frac{16}{64} = \frac{1}{4}$.

By adopting a series of standard stops such that each requires twice the exposure required by the next larger, lens manufacturers have done much to simplify exposure calculations. The standard series is:

$f/2$, $f/2{\cdot}8$, $f/4$, $f/5{\cdot}6$, $f/8$, $f/11$, $f/16$, $f/22$, $f/32$.

The maximum aperture, of course, may, and often does, come between two of these standard numbers. Continental lens manufacturers have adopted a series of f/Nos. similarly related, but starting with $f/1{\cdot}6$ and continuing as $f/2{\cdot}3$, $f/3{\cdot}2$, $f/4{\cdot}5$, $f/6{\cdot}3$, $f/9$, $f/12{\cdot}5$, $f/18$, $f/25$, and $f/36$.

When f/Nos. Vary. Since the f/No. is the focal length of the lens divided by the diameter of the stop, it follows that when one component of a doublet lens is used by itself, as it sometimes may be to form a lens of longer focal length, the marked f/Nos. are no longer correct. Their real values may be found by multiplying each f/No. by the focal length of the component and dividing by the focal length of the complete lens. This rule is not exact, but near enough for ordinary practical purposes.

Also, whenever any lens is used (for focussing a near object) so that it is racked out appreciably further than the position for focus on distant objects, the area of the image is increased. The f/No. becomes greater in the proportion of the focal distance (extension) to the focal length and the exposure according to the square of this proportion. The variation may be neglected so long as the extra extension is not more than about one-tenth of the focal length, but at greater extensions it becomes considerable, *e.g.*, when copying on an enlarged scale.

This allowance most frequently has to be made when copying originals on various scales. Usually the exposure is found by trial for same-size reproduction. The exposures for other scales of reproduction can then be calculated on the basis of the camera extension, the same lens and stop being used throughout. This is best done by providing the camera with a scale showing the extension beyond that for focus on distant objects, but graduated in focal lengths of the lens used instead of inches, *viz.*:—

$\frac{1}{4}f \quad \frac{1}{2}f \quad 1f \quad 2f \quad 3f \quad 4f$

The following table then shows the exposures (for any focal length of lens) compared with 1 second for same-size copying.

Extension on Scale	Focal Distance	Exposure is proportional to	Time of Exposure. Same size = 1 sec.	Scale of Reproduction, Linear
$\frac{1}{4}f$	$f + f/4 = 5f/4$	$25f^2/_{16}$	25/64, say $\frac{3}{8}$	$\frac{1}{4}$
$\frac{1}{2}f$	$f + f/2 = 3f/2$	$9f^2/_4$	9/16, say $\frac{1}{2}$	$\frac{1}{2}$
$1f$	$f + f = 2f$	$4f^2$	1	1
$2f$	$f + 2f = 3f$	$9f^2$	$9/4 = 2\frac{1}{4}$	2
$3f$	$f + 3f = 4f$	$16f^2$	$16/4 = 4$	3
$4f$	$f + 4f = 5f$	$25f^2$	$25/4 = 6\frac{1}{4}$	4

Lens Aperture and Depth of Field. If the focussing scale is set to give sharp focus at, say, 15 ft., then objects at 20 ft. and 10 ft. respectively will be less well defined, and objects at 25 ft. and 5 ft. respectively will probably be very much out of focus. There will, however, be a range around 15 ft. over which definition will be tolerably good. This range, known as depth of field, increases very markedly as the aperture of the lens is stopped down. Depth of field can only be quoted for a given degree of permissible unsharpness, and this is defined in terms of "circle of confusion." Points

of light in planes other than that which is sharply focussed are reproduced as circles which are cross-sections of the pencils of light coming to a focus either behind or in front of the sensitive surface. If these circles are small enough under the conditions of viewing to be considered as points, then subjects in the same plane will be rendered sufficiently sharply. It is generally assumed that prints will be examined at about 10 ins. from the eye, and that at this distance image discs not more than 1/100th of an inch in diameter are not distinguishable from points. If we assume that the print has been made (by contact or in the enlarger) to give correct perspective when examined at 10 in., then we can express the diameter of the circle of confusion in terms of focal length of the taking lens, that is to say, as $f/1000$.

Let us consider the matter from first principles:—

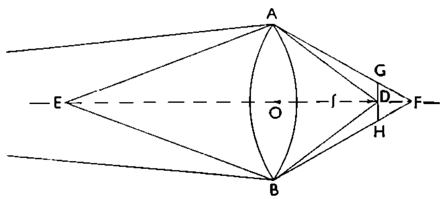


Fig. 15. Circle of confusion.

Suppose a lens $A\,B$ is focussed on a very distant object. This object will be imaged at D, so that the distance of D from $A\,B$ is equal to f. If now the depth of field is such that E is the nearest point to the lens which can be rendered in acceptably sharp focus, forming a small circular image in the plane of the film (actually it would be correctly focussed at F), then the diameter of this image, $G\,H$, is the diameter of the permissible circle of confusion. The relationship between E and its real image F is expressed by $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$. From this we have:

$$\frac{1}{u} = \frac{1}{f} - \frac{1}{v}$$

$$= \frac{v-f}{vf}$$

$$\text{and } u = \frac{vf}{v-f}$$

In the diagram this becomes

$$E\,O = \frac{O\,F}{D\,F}\cdot f = \frac{A\,B}{G\,H}\cdot f$$

where $A\,B$ is the effective diameter of lens and $G\,H$ the diameter of the circle of confusion.

Assuming the permissible circle of confusion to have a diameter equal to $f/1000$ then $E\,O$ is equal to $1000 \times$ effective diameter of the lens. $E\,O$ is known as the hyperfocal distance, and is defined as the distance from the lens of the nearest point which is sharply rendered when the lens is focussed on infinity. The smaller the hyperfocal distance then the greater will be the depth of field, and since hyperfocal distance is dependent only on the effective lens diameter it follows that short focus lenses, by giving bigger apertures for a given lens diameter, score heavily as regards depth of field. This is true even when we use, as we have done, an expression for the diameter of the circle of confusion which takes into account subsequent enlargement to give proper perspective under the conditions of viewing. Put shortly, this means that if from negatives made from a common view-point by two lenses having the same aperture but of different focal length, enlargements are made to give images of equal size, then the result obtained from the lens of shorter focal length will have the greater depth of field.

It follows from the above that hyperfocal distance is shortened, and depth of field correspondingly increased, as the lens is stopped down. If the effective diameter is cut down to half, the effective area is reduced to one quarter (equivalent to two stops), and the hyperfocal distance to one half.

HYPERFOCAL DISTANCES (in feet).

Based on a permissible circle of confusion of $f/1000$.

Focal Length, ins.	STOPS								
	f/1	f/1·4	f/2	f/2·8	f/4	f/4·5	f/5·6	f/8	f/11
1	84	60	42	30	21	19	15	11	8
1½	125	89	63	45	32	28	23	16	11
2	168	119	84	60	42	37	30	21	15
2½	209	149	105	75	53	47	38	27	19
3	—	178	126	89	63	56	45	32	23
3½	—	208	147	104	74	65	53	37	26
4	—	—	168	119	84	75	60	42	30
4½	—	—	189	134	95	84	68	48	34

Near and Far Objects. If the camera has been focussed on an object at a distance x and it is desired to know the range of distances over which sharp focus will be obtained, the information may be calculated from the following formula:

$$\text{Near distance} = \frac{H\,D \times x}{H\,D + x}$$

$$\text{Far distance} = \frac{H\,D \times x}{H\,D - x}$$

When $H\,D$ is the hyperfocal distance.

When two objects situated at different distances x and y from the camera are to be photographed, and it is required to know at which distance to focus the camera to obtain the best definition on both objects, the point is given by the expression

$$\frac{2\,x\,y}{x+y}$$

By using the table below, depth of field can be seen at a glance. To use the table, select the hyperfocal distance corresponding to your lens and to the aperture which you are using. From the distances set out opposite its hyperfocal distance take that one which corresponds most nearly to the distance of the object on which you are focussing. The limits of sharp definition are shown by the number before and the number after the distance focussed on.

DEPTH OF FIELD (table by R. de B. Adamson, B.Sc., of Christchurch, N.Z.).

Hyperfocal Distances	Distances Focussed on in Feet and Decimals of a Foot
200	Inf., 200, 100, 67, 50, 40, 33, 28·6, 25, 22·2, 20, 18·2, 16·7, 15·4, 14·3, 13·3, 12·5, 11·8, 11·1, 10·5, 10, 9·5, 9·1, 8·7, 8·3, 8, 7·7, 7·4, 7·1, 6·9, 6·7, 6·5, 6·3, 6·1, 5·9, 5·7, 5·55, 5·4, 5·25, 5·1, 5.
180	Inf., 180, 90, 60, 45, 36, 30, 25·7, 22·5, 20, 18, 16·4, 15, 13·9, 12·9, 12, 11·2, 10·6, 10, 9·5, 9, 8·6, 8·2, 7·8, 7·5, 7·2, 6·9, 6·7, 6·4, 6·2, 6, 5·8, 5·6, 5·45, 5·3, 5·15, 5.
160	Inf., 160, 80, 53, 40, 32, 26·7, 22·9, 20, 17·8, 16, 14·6, 13·3, 12·3, 11·4, 10·7, 10, 9·4, 8·9, 8·4, 8, 7·6, 7·3, 7, 6·7, 6·4, 6·15, 5·9, 5·7, 5·5, 5·3, 5·15, 5.
140	Inf., 140, 70, 47, 35, 28, 23·3, 20, 17·5, 15·5, 14, 12·7, 11·7, 10·8, 10, 9·3, 8·75, 8·25, 7·8, 7·4, 7, 6·65, 6·35, 6·1, 5·8, 5·6, 5·4, 5·2, 5.
120	Inf., 120, 60, 40, 30, 24, 20, 17·1, 15, 13·3, 12, 10·9, 10, 9·2, 8·6, 8, 7·5, 7, 6·7, 6·3, 6, 5·7, 5·5, 5·2, 5.
100	Inf., 100, 50, 33, 25, 20, 16·7, 14·3, 12·5, 11·1, 10, 9·1, 8·3, 7·7, 7·1, 6·7, 6·3, 5·9, 5·55, 5·25, 5.
90	Inf., 90, 45, 30, 22·5, 18, 15, 12·9, 11·2, 10, 9, 8·2, 7·5, 6·9, 6·4, 6, 5·6, 5·3, 5.
80	Inf., 80, 40, 26·7, 20, 16, 13·3, 11·4, 10, 8·9, 8, 7·3, 6·7, 6·15, 5·7, 5·3, 5.
70	Inf., 70, 35, 23·3, 17·5, 14, 11·7, 10, 8·75, 7·8, 7, 6·35, 5·8, 5·4, 5.
60	Inf., 60, 30, 20, 15, 12, 10, 8·6, 7·5, 6·7, 6, 5·5, 5.
50	Inf., 50, 25, 16·7, 12·5, 10, 8·3, 7·1, 6·3, 5·55, 5.
45	Inf., 45, 22·5, 15, 11·2, 9, 7·5, 6·4, 5·6, 5.
40	Inf., 40, 20, 13·3, 10, 8, 6·7, 5·7, 5.
35	Inf., 35, 17·5, 11·7, 8·75, 7, 5·8, 5.
30	Inf., 30, 15, 10, 7·5, 6, 5.
25	Inf., 25, 12·5, 8·3, 6·3, 5.
20	Inf., 20, 10, 6·7, 5.

The Resolving Power of a Lens. The image of a point source formed by a lens is a disc of diameter $2{\cdot}44\ \lambda f/d$ where λ is the wavelength of the light, d is the diameter of the lens, and f is the distance of the image from the lens. Thus, if the images of two points formed by the lens are situated just over half this distance apart, so that the distance between them is greater than $1{\cdot}22\ \lambda f/d$, they can be distinguished separately by the eye and the points are said to be resolvable. Actually, since the brightness of the image disc falls off towards the edge, it is possible to resolve points whose images fall even closer together than this. In the camera the resolving power depends not only on the lens, but also on the photographic emulsion. With special emulsions and well corrected lenses results of this order can be achieved, but with fast emulsions and less well corrected lenses the resolving power of the system is considerably reduced.

THE DEVELOPMENT OF THE PHOTOGRAPHIC LENS

The most elementary type of photographic objective is a simple convergent or positive lens. Any such lens of convenient focal length will form an image which can, under suitable conditions, be recorded on a plate or film as a photograph. The simple lens, however, exhibits a number of defects which can be briefly classified as follows:—

Defects of Lenses:

1. **Spherical Aberration.** This occurs because rays passing through the central zone of the lens and those passing through the peripheral zone come to a focus at different distances from the lens. Poor definition is the result.

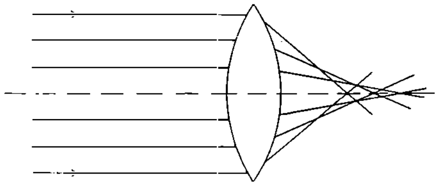


Fig. 16. Spherical aberration can be reduced by stopping down. In lens manufacture it is controlled by suitable choice of curvatures of the lens.

2. **Coma.** When oblique rays are subject to spherical aberration the image of a point becomes elongated and resembles a comet, usually with its tail pointing away from the axis of the lens.

3. **Astigmatism.** This is a cause of poor definition in images formed away from the axis of the lens. The image of a point object formed off the axis varies from a circle to a straight line according to the position of the focussing screen, and the rays do not anywhere come to a focus at a point. As a result an image is formed in which

vertical lines may appear sharp, while horizontal lines appear diffused or *vice versa*.

4. **Curvature of Field.** This causes a lack of sharpness at the edges of the picture when the centre is in focus. This defect arises from the fact that the oblique rays come to a focus at a point in front of the plane perpendicular to the axis through the focal point of the axial rays.

5. **Distortion.** Two varieties of distortion known respectively as "barrel" and "pin-cushion" are due to the diaphragm causing rays of different obliquity to pass through different parts of the lens. The image of a square object will, for example, have its sides bowed outwards or inwards according to whether the diaphragm is placed before or behind the lens.

6. **Chromatic Aberration.** Dispersion of white light passing through the lens results in the different coloured rays of which it is composed coming to a focus at different distances along the axis according to their wavelength, the shorter wavelengths being more strongly refracted. Both the position and the size of the image are thus affected according to the colour of the light.

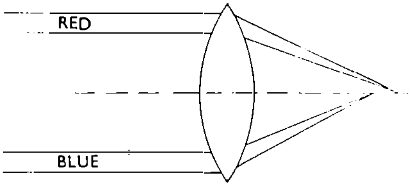


Fig. 17. In a lens showing chromatic aberration differently coloured rays do not come to a common focus. It can be corrected by using as second component a concave lens in which the dispersion is equal and opposite to that produced by the first lens.

It is the aim of the lens-maker to minimize these distortions and aberrations by adjusting the curves of the lens surfaces, by choosing glasses of suitable refractive index and dispersion, and in complex lenses by adjusting the distances separating the various components. The earliest contribution towards the correction of lenses was Dollond's invention in 1757 of the achromatic telescope objective. He achieved this by using a double convex lens made from crown glass of low dispersion cemented to a concave lens of flint, or lead glass, of high dispersion. In this way chromatic aberration can be corrected, and also to some extent spherical aberration.

At the time when a demand for photographic lenses first appeared with the introduction of the Daguerreotype and Talbotype processes, the experience from telescope practice was applied and single achromat lenses were used. This type of lens is subject to serious errors, but these can be eliminated to a large extent by working with a small diameter stop so that the image is formed by rays

passing mainly through the centre of the lens. The maximum aperture at which a single achromat can be used is about $f/14$, so that it is necessarily slow in working. Such lenses are still commonly fitted to box cameras and very cheap folding cameras, where cheapness is desired and speed is not essential, and give reasonably good results. The single lens was found too slow for portraiture, and many attempts were made to produce a lens which could be worked at a larger aperture. Opticians in the first half of the last century had a good understanding of the lines on which the problem could be tackled, but they were seriously handicapped by the very limited range of optical glasses available.

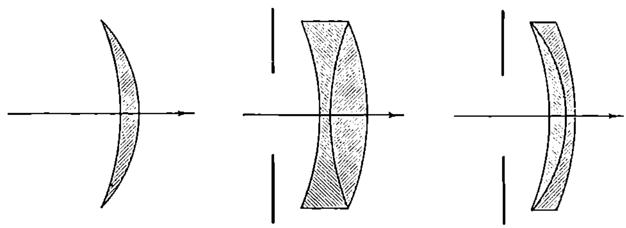


Fig. 18. Single meniscus. Achromatic landscape lens of Chevalier. Grubb's landscape lens.

One of the most successful of the early fast lenses was the portrait lens computed by J. Petzval in 1841. In modified form this lens has survived almost to the present day. It consists of two dissimilar and widely separated achromatic combinations (Fig. 19), the first pair

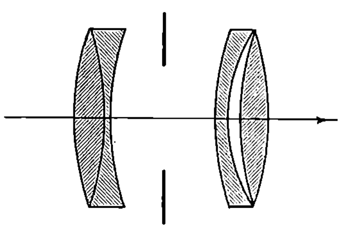


Fig. 19. Petzval portrait lens.

being cemented together, and the back pair separated by an air space. Although the Petzval lens shows serious defects, particularly astigmatism and marked curvature of field, which results in poor definition over all but the centre of the field, it can be worked at a large aperture. Lenses suitable for portraiture were commonly made covering a small angle, having an aperture of $f/4$, and one working at $f/2{\cdot}2$ was produced by Dallmeyer as early as 1860. The poor definition gives a characteristic softness which is not unpleasing in portraiture. Modern "soft focus" lenses are modified

Petzval lenses in which the "softness" is controlled by altering the degree of separation of the two components, and so introducing a varying amount of spherical aberration. The Petzval lens has also found application for projection purposes.

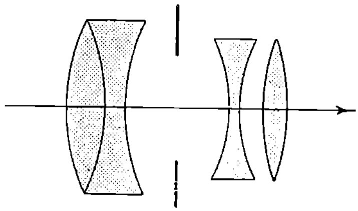


Fig. 20. Steinheil's Antiplanat.

Fig. 20 illustrates a type of unsymmetrical doublet which was introduced by A. Steinheil as an improvement on the Petzval lens. Working at $f/4$, it is practically free from astigmatism over a small angle. It is of interest mainly on account of its similarity to some modern anastigmats. Known as the "Antiplanat," this lens could almost be classed as a triplet. In a later form, however, Dr. Steinheil employed a cemented lens in place of the two separate glasses of the back combination.

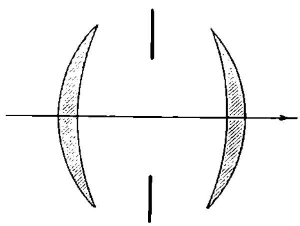


Fig. 21. Steinheil's "Periskop" lens—the first of the symmetrical doublets. By placing the diaphragm between the lenses the distortions were neutralised.

Next in importance from the historical point of view are the symmetrical doublets. The earliest of these was the "Periskop" lens introduced by Steinheil in 1865, following an arrangement similar to that used by Wollaston for microscope objectives. It consisted of two plain meniscus lenses separated by a central diaphragm, and was fitted at one time to fixed-focus cameras. It is free from distortion and gives a flat field, but is not achromatic and therefore must be adjusted to its "chemical" focus, *i.e.*, focus for blue-violet light. Needless to say, it would not give very good results with modern panchromatic emulsions. The most familiar form of the symmetrical doublet is the rapid rectilinear lens which was commonly fitted to hand cameras a quarter of a century ago. It is similar to the "Periskop" except that simple meniscus lenses

are replaced by achromatic combinations. These lenses were usually made to work up to a nominal aperture of *f*/8, and gave excellent results. Astigmatism is, however, always present, and at full aperture the marginal definition is not perfect, so that for critical work stopping down is advisable.

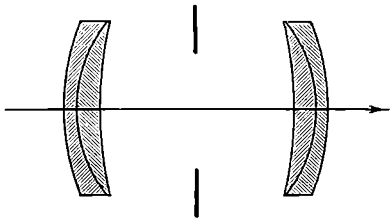


Fig. 22. Rapid rectilinear lens. Steinheil and Dallmeyer independently introduced symmetrical doublets, in which the component glasses of each single achromat were both flints, with the result that astigmatism was reduced.

Although the need for optical glasses of a greater range of refraction and dispersion had been recognized for many years, no very systematic research had been done on this problem until Abbe and Schott in Germany applied themselves to it about the year 1880. Actually, a committee of the Royal Astronomical Society had reported on the desirability of research in this direction as early as 1824, and Faraday had interested himself in the problem. His experiments were directed, however, more to improving the quality of lead glass by ensuring homogeneity than to producing new glasses. Abbe and Schott, aided by grants from the German Government, produced a whole series of glasses of novel composition; they introduced elements such as magnesium, barium, aluminium, zinc, and boron, which were practically unknown in previous glass-making practice. By these means they evolved glasses of the greatest value, and of widely different optical properties, from the simple glasses previously available. The long-sighted policy of the German Government of the day in subsidizing these two workers not only conferred a benefit on the rest of the world, but was the means of establishing in Germany an optical industry which grew to be of great importance. The chief defect of the old glasses from an optical point of view was the relation between refraction and dispersion, since both these properties showed a tendency to increase regularly with increasing density of the glass. Abbe and Schott were able to produce some glasses in which a high dispersion was associated with a relatively low refractive index, and others in which the reverse was the case. Many of the first lenses produced with the new glasses were on the lines of the old symmetrical doublet, and they were frequently arranged so that each component could be used separately as a lens of greater

focal length than the combination. These "convertible" or divisible lenses enjoyed considerable popularity at that period.

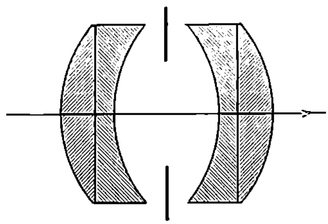


Fig. 23. The Ross concentric lens. Aperture limited, but covering a wide field.

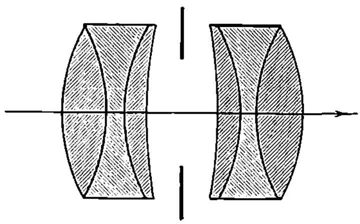


Fig. 24. Goerz Dagor.

Fig. 23 shows the Ross concentric lens of 1892, and Fig. 24 the Goerz Dagor. The peculiarity of the concentric is the use of plano convex crowns and the fact that the exposed surfaces are concentric. The Dagor employed a combination of triple cemented glasses, and gave a flat field with freedom from astigmatism up to an aperture of $f/7{\cdot}7$, later increased to $f/6{\cdot}8$.

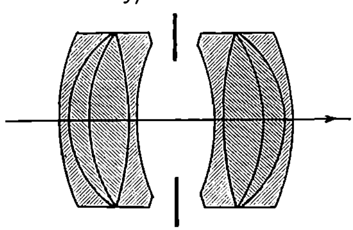


Fig. 25. Zeiss Protar.

The Zeiss Protar (Fig. 25) is an extension of the same principle, a pair of quadruple components being used. Each component consists essentially of an achromat of the old type cemented to an achromat made from the newer glasses. Protars were made to work at $f/6{\cdot}3$ when complete, or at $f/12{\cdot}5$ when the components were separated and used singly.

A single Protar was said to give the highest correction possible with a single lens.

Not only is it possible to use a pair of similar Protars together, but a combination can also be made from a pair of components having different focal lengths. With the latter arrangement a choice of three focal lengths becomes available by using one or other of the lenses singly, or the pair in combination.

Lenses similar to the Zeiss Protar have been produced with five cemented glasses to each lens, but the high cost of manufacture is a serious disadvantage.

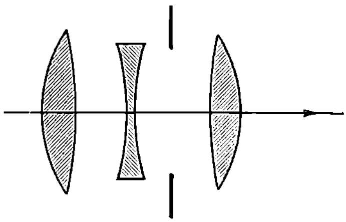


Fig. 26. Cooke lens.

The Cooke lens, introduced about 1895, makes a distinct departure, and is notable for its simplicity of construction. It consists (Fig. 26) of three single separated lenses, two of which are convex lenses of crown glass of high refraction and low dispersion. They are separated by a biconcave lens of light flint glass, which serves the purpose of flattening the field. The Cooke lens bears a resemblance to the old Antiplanat lens of Steinheil shown in Fig. 20.

In its first form it was intended for portraiture and designed to work at an aperture of *f*/4·5 and later at *f*/3·5, but modified lenses on the same plan have been produced for other purposes, including highly corrected process lenses.

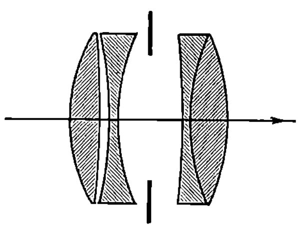


Fig. 27. Zeiss Tessar.

The well-known Zeiss Tessar lens (Fig. 27), often fitted to good-class modern cameras, is not unlike the Cooke lens (Fig. 26); a cemented meniscus is used for the back element in place of the plano-convex glass of the Cooke portrait lens. The Tessar is issued in a large range of apertures and focal lengths, which include some very fast lenses. The Aldis lens, produced by H. L. Aldis in 1902, is shown in Fig. 28. Consisting of a single meniscus and two cemented lenses, it is remarkable for its simplicity. Good correction can be obtained by this construction, and open or reflecting surfaces are avoided.

Fig. 29 illustrates a lens which is of some historical interest. Petzval, after devoting considerable time to the problem, came to the conclusion that it was not possible to make a lens approaching perfect correction with the old optical glass, and this view was very generally held. Martin, of Messrs. Busch, showed, however, that it was quite possible to do so by using a system of separated lenses and making use of the refraction of the air spaces. Busch issued a series of anastigmats constructed on this plan, which were made in apertures up to $f/4\cdot5$, and known as the "Omnar" series. A disadvantage of this system is the number of reflecting surfaces, which has a tendency to impair the performance of a lens when it is used at less than its maximum aperture.

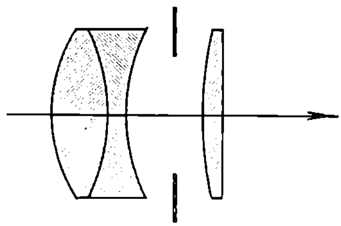


Fig. 28. Aldis lens.

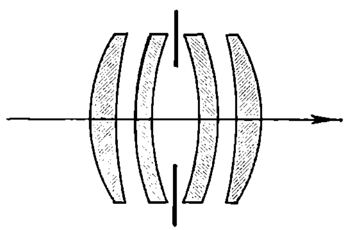


Fig. 29. Busch Omnar lens.

The Telephoto Lens. By placing a suitable negative lens behind an ordinary objective, the pencil of rays is rendered less convergent and comes to a focus as though it had been formed by an objective of much greater focal length. The required camera extension, however, is very much less than would be needed for such a long focus lens. On this principle *telephoto attachments* were formerly used in conjunction with ordinary lenses for obtaining a variety of focal lengths with relatively short camera extensions. This system yielded focal lengths much too great for general utility and resulted in greatly reduced working apertures. It has now been very largely replaced by complete *telephoto lenses*, affording focal lengths twice or three times the camera extension which they respectively require, and having maximum apertures ranging from $f/10$ to $f/3\cdot5$. Except that it projects a considerable distance in front of its flange, this type of lens can be used like any other, gives definition comparable with

that of a good anastigmat, and allows pictures twice or three times the normal size (linear) to be obtained with single-extension cameras. These lenses are very useful for obtaining pictures on a larger scale in the case of distant subjects. Moreover, they allow this long-focus effect to be obtained with cameras of only single extension. So far as their use is concerned, these fixed-focus telephoto lenses differ only in one respect from ordinary anastigmat objectives. The difference is due to the type of construction, and relates to the manipulation of the camera when photographing a subject containing vertical lines and with the camera in a tilted position. In the use of an ordinary lens the camera back needs to be swung so as to bring the plate or film into a vertical plane, otherwise parallel lines in the subject will be shown as converging upwards. This is not the case, however, with a telephoto lens. Here, in the same circumstances, the camera back must be swung forward through only part of the angle (approximately half) which would bring the plate or film into the vertical plane.

Apart from these fixed-focus telephoto lenses, a photographer's chief interest in lenses of this kind applies to those which afford a great range of focal lengths by adjustment of the separation between the positive and negative parts of the objective. While the uses of such great focal lengths are comparatively rare, these instruments can at times render useful service, such as in photographing inaccessible architectural detail or in obtaining very narrow angle views of subjects from a height which cannot be satisfactorily seen from the ground level. For such work the user chiefly requires to know the relative aperture at which the lens works with a given camera extension. For this purpose the ordinary method of measuring focal length cannot be applied. The best plan is to set up another camera side by side with that to which the telephoto is fitted and provided with a lens of known focal length. If now the size of the image of a definite large distant object be measured on the focussing screens of the two cameras, the focal length of the telephoto can be readily calculated, since it will be that of the lens on the other camera multiplied by the ratio of the linear sizes of the telephoto and ordinary images respectively. Thus, if the telephoto image is twice that given by a lens of 12-in. focal length, the equivalent focal length of the telephoto at this setting is 24 in. The working aperture may then be found in the usual way by dividing the focal length by the diameter of the lens stop.

Enlarging Lenses. In general, camera objectives may be used quite satisfactorily as enlarging lenses, although it is true to say that some which give a flat field with distant objects do not do so when used in the enlarger. Generally speaking, this defect can be overcome by stopping down. As regards freedom from distortion and from transverse chromatic aberration, the best lenses are of the symmetrical type.

CHAPTER II

CAMERAS

●

The camera is essentially a light-tight enclosure with a lens at one end and a fitting to take the light sensitive film or plate at the other. Generally the lens is situated directly opposite the centre of the sensitive material, but in many cameras this relationship can be altered. In all but the simplest and cheapest cameras, in which fixed focus lenses are used, it is necessary for the lens-plate or lens-film distance to be variable, and this is achieved by sliding the front part of the camera bearing the lens backwards and forwards or by rotating the lens-mount. Light is normally prevented from reaching the sensitive material by the shutter, the mechanism of which is so designed that it can be actuated at the will of the operator, and one of a series of short exposures given automatically. The amount of light reaching the plate or film for a given exposure time is determined by the diaphragm, in which is incorporated a series of apertures or "stops," varying in size and number according to the lens employed.

Many types of camera have been designed for different classes of work, and, in making a choice, it is of importance to see that the camera is substantial and accurate in the movement of its parts. When in doubt as to the best type of camera to buy, it is well to remember that the more elaborate patterns, while offering greater scope, also provide more opportunities for making mistakes.

In recent years the tendency has been to make photographic equipment as little cumbersome as possible. Simplification as such has not been sought after so assiduously—but the aim of camera manufacturers has been to avoid personal judgment as much as possible and to replace it by measurement. For this reason modern cameras often have built-in range-finders, and sometimes exposure meters are incorporated.

Hand cameras fall into three main classes:—

(1) For Daylight Loading Roll Films in which the sensitive film is in the form of a band, backed with duplex paper and wound on a spool. The duplex paper projects beyond both ends of the film so that loading and unloading can be carried out in daylight.

(2) For Plates and Film Packs. Plates are carried in separate holders or darkslides which are loaded and unloaded in the dark-room. Film packs consist of separate pieces of film in a light-tight case, arranged in such a way that they are brought successively into position for exposure whilst the case is affixed to the camera back.

(3) Miniature Cameras taking relatively long lengths of small width film without paper backing. Such cameras commonly take

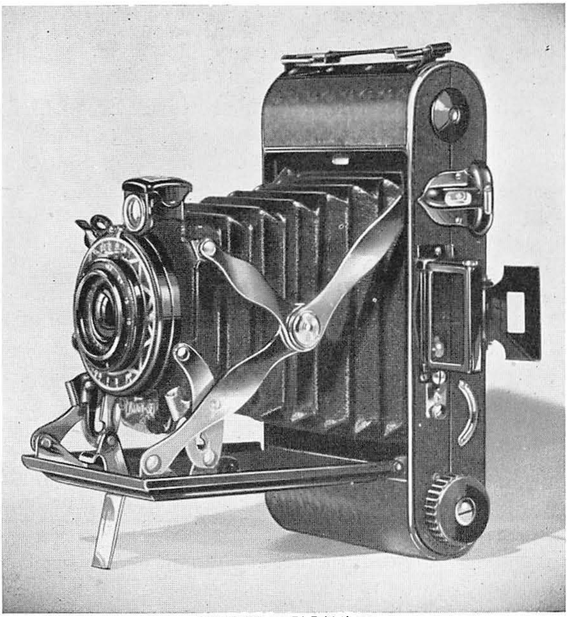
35 mm. perforated film in daylight loading cassettes or on spools with paper leaders and trailers.

With cameras taking plates or film packs the picture can, if desired. be seen and focussed on a ground glass screen, whereas this cannot be done with a roll film camera unless it is of the reflex type. Most kinds are, however, fitted with finders of various types which will be described in a later section.

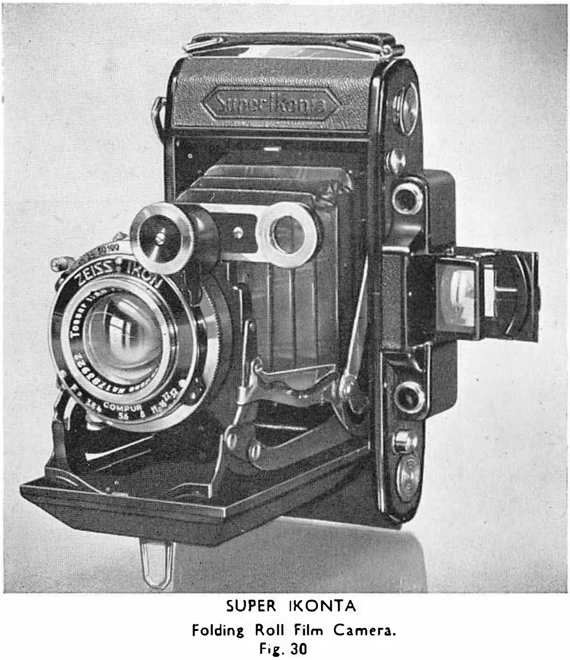
Box Cameras. The simplest pattern of roll film camera is the box form, which, in the sizes $3\frac{1}{2} \times 2\frac{1}{2}$ in. and $4\frac{1}{2} \times 2\frac{1}{2}$ in., is very convenient to handle and requires the minimum of experience since focussing is dispensed with. Box cameras of this type give sharp pictures of all objects at distances of 10 ft. or more from the camera, and thus are known as fixed focus cameras. The lenses available are not, of course, of large aperture, but with modern high-speed films this is not as great a disadvantage as was once the case. With many fixed focus cameras it is possible to obtain "portrait attachments" or supplementary lenses by means of which objects between 3 ft. and 10 ft. from the camera may be brought into sharp focus.

The cheaper box cameras are fitted with ground glass view finders—the more expensive varieties have "brilliant" finders. The shutters employed are usually of a very ingenious but simple type.

Folding Roll Film Cameras. In this class sizes range from $2\frac{5}{8} \times 1\frac{5}{8}$ in. to $5\frac{1}{2} \times 3\frac{1}{2}$ in., and in quality from the cheapest to the most expensive. $3\frac{1}{4} \times 2\frac{1}{4}$ in. is by far the most popular size. In the simplest pattern the camera front automatically comes into position when the camera is opened. There is no focussing, and such cameras operate exactly the same as other fixed focus cameras of the box form type. With most patterns, however (those fitted with lenses of $f/8$ or larger aperture), provision is made for focussing and the lens is moved forward or backward, either by movement of the bellows or by rotation of the lens mount, to points at which it is to be set for focus on objects at various distances. These distances must be judged by the eye, and the lens set accordingly. Especially with lenses of large aperture and considerable focal length the judgment of distance must be made very accurately, and this calls for experience and skill or for the use of a range-finder. Hence for sizes $3\frac{1}{2} \times 2\frac{1}{2}$ in. and larger, lenses of $f/4{\cdot}5$ aperture are the most rapid which are advisable for general use. For the smaller cameras lenses of $f/3{\cdot}5$ or even $f/2$ aperture may conveniently be used. Good quality roll film cameras are fitted with "brilliant" view-finders and sometimes also with direct finders of the wire frame type. In the cheaper folding cameras, shutters giving instantaneous exposures up to 1/100th second are employed. In these the movement of the shutter is directly effected by tension set up in a spring by the pressure applied by the operator. In the more expensive instruments, shutters of the Compur type are used in which the shutter is pre-set and



ENSIGN "SELFIX" 20.
Folding Roll Film Camera.



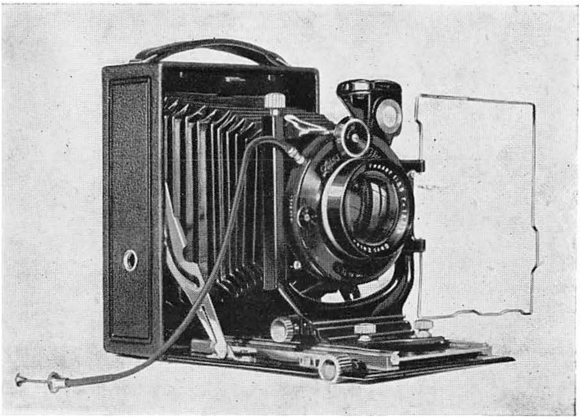
SUPER IKONTA
Folding Roll Film Camera.
Fig. 30

which employ trains of gear wheels or escapement devices. In such cases the shutter is only triggered off by the finger of the operator. Speeds up to 1/250th are commonly available, and sometimes there is a supplementary spring to give still higher speeds.

Some roll film cameras are provided with devices which prevent the taking of two exposures on one piece of film, for instance, the shutter may be set by the action which moves the film forward. In the more highly priced cameras the chief points of distinction concern the quality of construction and type of lens. Other features include the provision of vibrationless body shutter releases and of a "rising front" adjustment which makes possible the movement of the lens above or below the central position. When the lens is raised, the upper part of a subject can be included at the expense of the foreground whilst the camera is held level. If this effect is obtained by tilting the camera upwards, vertical lines are rendered convergent.

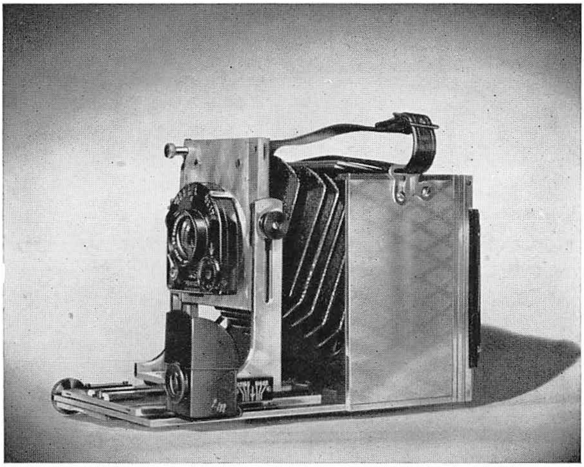
Further features of the modern De Luxe Roll Film Camera are the built-in range-finder and the combined range-finder-view-finder, which in some patterns is coupled direct to the lens mount so that focussing becomes completely automatic. A particularly interesting modern roll film camera is the Super Kodak Six 20, which possesses a combined range-view-finder and an exposure selecting meter. In the range-finder, rotation of the lens mount causes one of the two finder objectives to be moved at right-angles to the beam of light passing through it. The object seen is in focus when the part images from the two window objectives link up. The shutter is set by the film-winding mechanism and for speeds of 1/25th second and faster, the required aperture is selected automatically by a photo-electric cell assembly. The power which actuates the diaphragm blades is supplied by a spring pre-set by the movement of the winding lever and released by tripping the shutter mechanism. The current from the photo-electric cell operates a galvanometer coil carrying a long pointer, and the first act of the shutter mechanism is to lock this pointer in whatever position it may be. This position determines the setting of the diaphragm. By modifying the galvanometer response an open scale has been obtained.

Hand Cameras for Film Packs and Plates. In design these are largely on the lines of folding roll film cameras. One or two models are made for film packs only, the holder of the pack forming part of the camera back, but by far the greater number are designed to take both single plate-holders of thin metal and a loose adapter into which the film pack fits. The user thus has the advantage of employing plates of kinds suitable for various purposes, and also film packs with their added facility of daylight loading. As regards focussing, rising and cross-front movements, and finders, these cameras are modelled on the better patterns of instruments for roll film.



ZEISS FOLDING PLATE CAMERA.

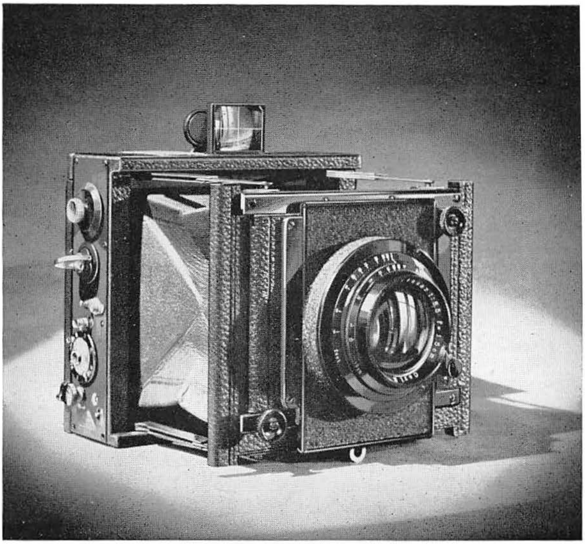
Double extension rising and cross front, fitted with Zeiss Tessar F. 3.5 lens in Compur Shutter.



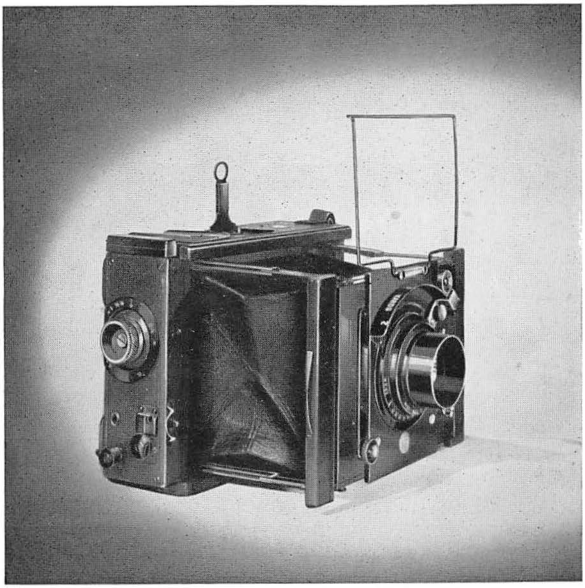
SINCLAIR "TRAVELLING UNA"

A metal camera of the highest class.

Fig. 31



ANCHUTZ PRESS CAMERA.



V.N. PRESS CAMERA.

Fig. 32

Double Extension Cameras. For use with either roll films or plates, folding cameras may be obtained in which the lens can be racked out to a distance about equal to twice its focal length. This pattern makes it possible to copy objects nearly same size and also allows one to use a lens of much longer focus, *e.g.*, the half of a doublet lens with which the camera may be fitted. Under some circumstances photographing at this double extension can be done in the hand by means of the extra focussing scale provided, but as a rule it is necessary to focus the picture on the ground glass, and. therefore, when purchasing a camera of this pattern one should choose a model designed for use with plates and be prepared to use it on a tripod or other firm support.

Folding Focal-plane Cameras. A pattern of camera which was for many years the most popular for press photography is the folding focal-plane (Fig. 32), the special features of which are (1) the system of holding the front in the extended position by means of two pairs of spring struts, and (2) the shutter consisting of a flexible blind (or pair of blinds) moving close in front of the sensitive surface and arranged to expose the plate through a slit. This focal-plane shutter is able to give very short exposures up to about 1/1000th second. The large and rigidly supported front of the camera makes it possible to fit lenses of very large aperture, adjustment for distance being made by rotation of the lens mount. For professional press work the most favoured sizes are 5 × 4 in. and 9 × 12 cm. Amateurs who wish to undertake rapid sports photography can obtain smaller focal-plane cameras in several makes. The desire for small size cameras is not confined to amateurs, however, because many press photographers are now using miniature cameras for all their work.

Reflex Cameras. In these cameras the image formed by the lens **L** (Fig. 33) is obtained full size, the right way up, but reversed as regards right and left on a focussing screen S placed horizontally at the top of the camera. This results from the interposition of a mirror M at an angle of about 45°. When the mirror is moved up it seals the camera against the entrance of light through the focussing screen, and at the same instant operates a focal-plane shutter by which the film or plate P is exposed to the direct rays from the lens. The advantages of this arrangement are: (1) The picture is seen in full brilliance through the aperture of the hood H, so that the subject can be arranged to a nicety and equally so when the rising and falling front of the camera is used. (2) The focus of the picture can be judged up to the instant of exposure, and focussing is as easy and exact with lenses of the largest aperture as with those working at a small stop. (3) These facilities are obtained without any alteration to the camera when using lenses of different focal lengths.

The chief drawback of the reflex camera is its bulk. Folding

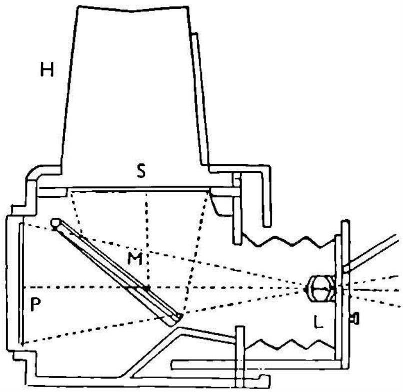


Fig. 33. Diagram of Reflex Camera.

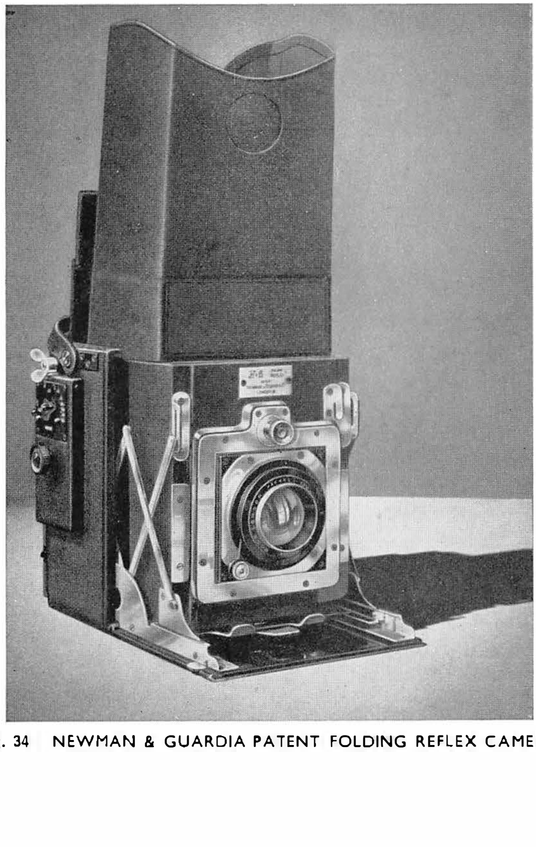


Fig. 34 NEWMAN & GUARDIA PATENT FOLDING REFLEX CAMERA.

patterns are obtainable, but the reduction in bulk is not very great, whilst the manipulation for opening and closing is a handicap. Most reflex cameras are constructed to take plate-holders or a film-pack adapter, but several can be obtained for use with roll film.

Although somewhat more bulky, the square-pattern box reflex is greatly to be preferred. The rear focussing screen (and plate-holder or film-pack adapter) is carried on a rotating back which can be placed for either oblong or upright pictures. In the absence of this provision, the camera must be held sideways for one or other of the two styles of picture—a most awkward proceeding.

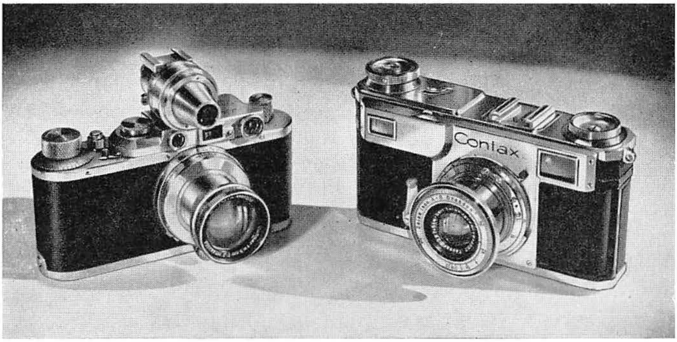
One thing is important in the design of a reflex, and that is instant accessibility of the focussing screen for dusting or wiping. If the screen is very dusty or has drops of water on it, focussing cannot be done properly. The hood should be hinged or detachable, so as to allow of the focussing screen being uncovered without any trouble.

Although the contrary is often stated, it is better to have the focussing head and shutter release on the same side of the camera. One hand is then used solely for holding the camera firmly, whilst the other operates first the focussing pinion and then the shutter release. The idea that, with the focussing head on one side of the camera and the shutter release on the other, one can keep an approaching object in focus until the instant of exposure, is not practicable.

Twin-lens Reflex Cameras. The twin-lens reflex has recently become a very popular type of instrument. One lens projects the image upon the sensitive surface while the other serves for focussing. The lenses are mechanically coupled so that the focussing adjustment affects both. It is possible to have the focussing lens of longer focal length than the taking lens in order to get a large image on the viewing screen, and the use of such a focussing lens with its smaller depth of field tends to ensure sharp pictures. In certain cheap twin-lens cameras the lenses are not coupled, and the viewing system is simply a particularly large finder.

Miniature Cameras. It is probably true to say that this type of camera dominates amateur photography to-day. There is nothing essentially novel about such cameras, because small cameras have been produced from time to time ever since Fox Talbot made his first "mousetrap." In late years, however, they have become much more ambitious, and now the miniaturist is usually quite willing to undertake any branch of photographic work, however difficult and complicated it may be.

The miniature camera starts off with several important advantages. In the first place it is possible to get lenses of very wide aperture, which are not economic propositions in the larger sizes. Secondly, depth of field is a function of the lens diameter, and so for a given

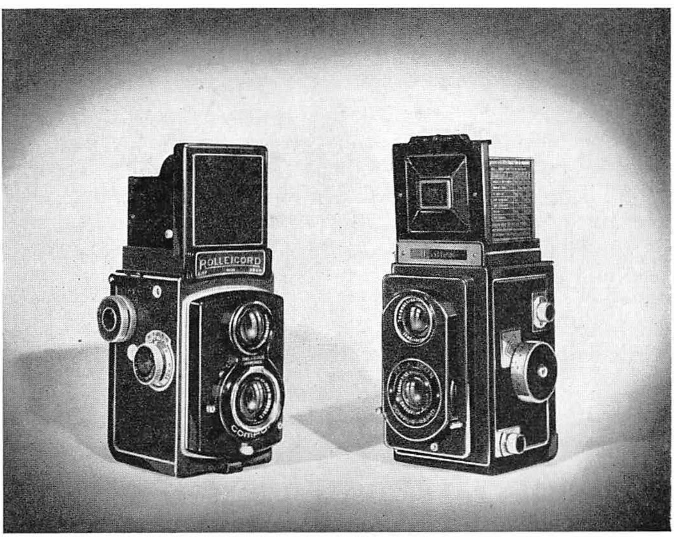


THE LEICA AND CONTAX CAMERAS.

The illustration shows the Leica II on the left with the Summar F/2 lens and Universal (vidomchrom) finder.

On the right is shown the Zeiss-Ikon Contax II camera with F/2.8 Zeiss Tessar.

The two miniature cameras shown above both take Selo 35 mm. film in their respective daylight loading cassettes.



ROLLEICORD AND IKOFLEX CAMERAS.

A pair of typical Twin lens Reflex cameras taking size 20 roll film and producing a picture size 6 x 6 cm. or 2¼″ x 2¼″.

On the left the Rolleicord II fitted with a F/3.5 Zeiss Triotar lens in Compur shutter.

On the right the Zeiss-Ikon Ikoflex III fitted with a Zeiss Tessar F/3.5 anastigmat in Rapid Compur shutter.

Fig. 35

aperture the miniature using a short focus lens has a considerable advantage in this respect. This is true after making all allowances for different sized images, etc. There are disadvantages, of course, in that all processing operations must be carried out with extreme care since blemishes and faults are relatively more important and less easy to deal with in the smaller size film. Negative retouching is practically impossible, and the graininess of the photographic emulsion is a constant enemy. When using the camera great care must be exercised to avoid camera shake, which is the cause of ninety per cent. of the unsharpness often seen in enlargements made from small negatives. It is doubtful whether anything longer than one-hundredth of a second is safe for a hand-held exposure by the average photographer using a miniature camera.

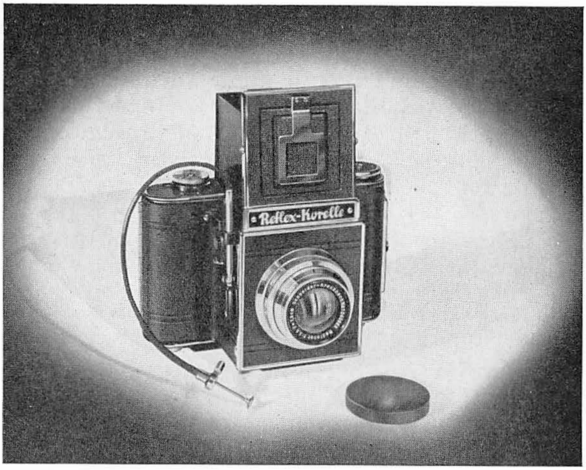
Miniature cameras taking lengths of 35 mm. perforated film include the Leica, Contax, Contaflex, Retina, Karat, Robot, etc., and for all these, suitable cassettes or daylight loading spools are available. All the above are straight cameras with the exception of the Contaflex, which is a twin-lens reflex with a focussing lens of focal length $3\frac{1}{8}$ in. (against the taking lens of 2 in.) forming a particularly brilliant image. This camera also has a built-in exposure meter.

Contax. One of the most popular 35 mm. cameras is the Contax; particular advantages claimed for it include the all-metal construction (including the focal-plane shutter which gives $\frac{1}{2}$ to 1/1250 sec. exposure); shutter coupled with film transport mechanism; the swing wedge range-finder-view-finder; availability of wide aperture lenses; interchangeability of lenses; placement of shutter release on camera body; simplicity of loading and availability of alternative plate back. The Contax III has a built-in exposure meter.

Film for the Contax is normally packed in the form of a spool, having a leader and trailer of paper perforated like the film. It travels once only through the camera, being taken off on the take up spool, and is not rewound. Film transport and shutter wind are coupled so that two exposures on one film are impossible.

Leica. Particular features of the Leica camera include precision workmanship throughout, coupled film transport and shutter mechanism, built-in range-finder and interchangeable lenses. Focal-plane shutter giving speeds from 1 sec. to 1/1000 sec. The Leica was the first of the modern miniatures, and immediately set the highest of standards. The usual film packing is the daylight loading cassette taking 36 exposures, and the film is normally rewound into the cassette after use. Refills for the cassettes are supplied by all film manufacturers, and some also provide their own type of daylight loading cassette. Special Leica models taking 250 exposures are in existence.

Robot. The Robot takes a number of exposures one after another at extremely short time intervals, without rewinding, so that a series



KORELLE ONE LENS REFLEX

6 x 6cm. Camera (Roll Film) with F/3.5 Radionar Lens and Focal Plane Shutter.

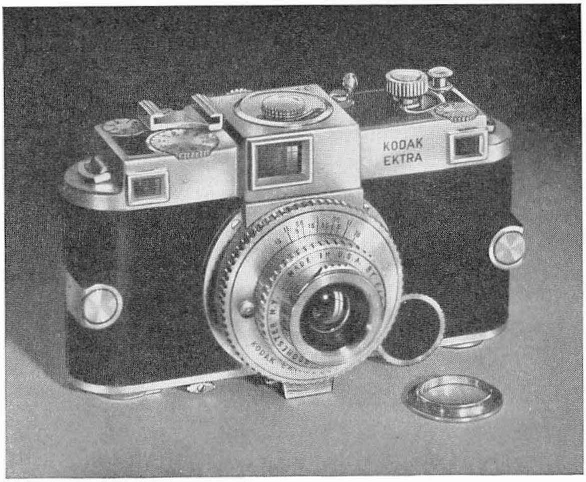


Fig. 36. KODAK EKTRA 35mm. CAMERA.

Magazine backs make it possible to change from one type of film to another at will. Six interchangeable lenses all work automatically with rangefinder. Focal plane shutter, etc.

of pictures can be taken of a subject in motion to provide material for an analysis of that motion.

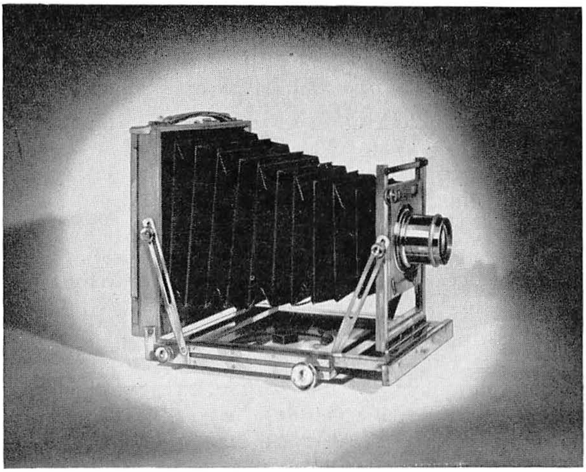
Also included in the miniature range are the cameras taking pictures $2\frac{1}{4}$-inch square on No. 20 roll films. These include the twin-lens reflexes—Rolleiflex and Rolleicord. The Rolleiflex is the more expensive model. It is supplied with Zeiss Tessar lenses, and a Compur shutter giving 1/500 sec. exposure. The Rolleicord is supplied with Zeiss Triotars and a Compur shutter giving 1/300 sec. exposure. In the design of both cameras compensation has been made for parallax errors. The standard Rolleiflex and Rolleicord take 12 pictures on No. 20 roll film, 6 × 6 cm., and the Sports Rolleiflex 12 exposures on No. 27 films, 4 × 4 cm. The Auto-Rolleiflex takes 12 exposures on No. 20 film similar to the Rolleicord.

A true miniature reflex camera is the Exakta, which takes No. 27 films, giving 8 negatives of picture size 4 × 6·5 cm. As with all true Reflex cameras, the image seen is exactly that which will fall upon the photographic film—there can be no error due to parallax. The self-capping focal-plane shutter gives a range of exposures from 12 seconds to 1/1000th second. A series of interchangeable lenses is available with apertures up to *f*/1·9.

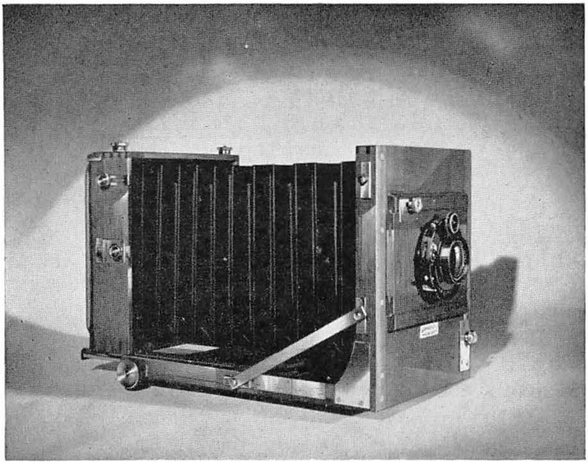
Stand Cameras. This section includes the cameras in use in Professional Studios. Cameras of the large sizes (10 × 8 and 12 × 10 ins.) are now much less commonly employed, since prints equal to those made by contact can usually be obtained as enlargements from smaller negatives. Hence the whole-plate ($8\frac{1}{2}$ × $6\frac{1}{2}$ ins.) is perhaps the most favoured size for professional use.

Stand cameras are of two principal types. The older and heavier pattern (Fig. 37b), now less frequently used, is made with a square bellows and a solid baseboard, in which is the "bush" for the screw securing the camera to the tripod top. In the light-weight model (Fig. 37a), now popular, the bellows are tapered, and the baseboard is a frame-work with a circular aperture fitted with a metal frame (a turntable), to which the legs of the tripod are separately attached and on which the camera can be rotated. This pattern is awkward for cameras much larger than half-plate because of the difficulty of supporting the weight whilst attaching each tripod leg.

A stand camera should allow ample rising and falling movement of the lens. If the range of this movement is great (*e.g.*, a rise equal to three-eighths the longer dimension of the plate), there is little advantage in a swinging or tilting movement of the lens provided on some cameras. This latter, however, serves in a measure to compensate for the lack of the larger covering power required when a lens is used much above the centre of the plate. So also does the *swing back*, by which the plate or film is restored to the vertical when the camera is tilted without use of the rising front. In each case the lens remains pretty nearly opposite the centre of the plate, but is



TYPICAL TAPER-BELLOWS STAND CAMERA (Adams).



TYPICAL SQUARE-BELLOWS STAND CAMERA (Gandolfi).
Fig. 37

arranged obliquely towards it instead of at right-angles. In these circumstances sufficiently sharp definition can be obtained by using a small stop. Whichever kind of adjustment is adopted, the sensitive surface must be vertical when photographing subjects containing definite vertical lines, otherwise these will be rendered as converging to a point above or below the subject.

The swing front and swing back serve another purpose of occasional utility in landscape photography, *viz.*, that of obtaining sharpness of a near part of the subject on the right (or top) and of a distant part on the left (or bottom) without using a much smaller stop. In many cameras this same facility is provided by the *side swing* of the back. The back can be angled relatively to the front as though moved on a vertical axis. The models in Fig. 37 show the two forms of swing back, the second type affording the greater range of movement.

A light-weight camera, owing to its less substantial build, should be fitted with racking movement to both front and rear, as shown in the first illustration in Fig. 37. Better balance is obtained when the camera is fully extended. Another advantage is that the back can be racked towards the front when using a wide-angle lens, thus obviating a projecting baseboard which might intercept rays which should reach the lens from the foreground of the subject.

As regards extension (distance from focussing screen to lens panel), makers of light-weight cameras are exceedingly generous. In half-plate size an extension of 22 in. is usual, whilst some models provide 28 in. or more. In any stand camera for all branches of photography, an extension 4 to 5 times the longer dimensions of the plate is desirable so as to allow of the use of long-focus lenses and of copying on an enlarged scale. At the same time preference should be given to a model of substantial build, since rigidity of the baseboard and of the front and back on it becomes of increasing importance as the instrument is used at a long extension.

CAMERA ACCESSORIES

View-finders. With studio and stand cameras generally, it is usual to compose the picture on the ground glass before the plate or film is placed in position. In the case of the true reflex, the full-sized image can be seen upon the focussing screen right up to the moment of making the exposure, but is not visible during the making of the exposure. The twin-lens reflex has one lens projecting an image on the screen and, in this case, the image can be seen whilst the exposure is being made. Smaller cameras employ separate finders, in most of which a very reduced image is seen, and some have in addition direct-vision finders incorporating a peep-sight and a wire frame to define the acceptance angle. The simplest finders are essentially miniature reflex cameras using a positive lens of 1-inch focal length, a mirror inclined at 45° and a ground glass upon which the image is

focussed. "Brilliant" finders, as fitted to the medium priced cameras, employ a second positive lens with a mask cut to show the limits of the picture when the camera is in the vertical and horizontal positions.

A very satisfactory type of direct-vision finder is that which employs a strongly diverging lens to form a virtual image which is viewed through a weak positive lens. The combined effect of the two lenses is to produce a virtual image, erect and right way round, at a distance of about fifteen feet.

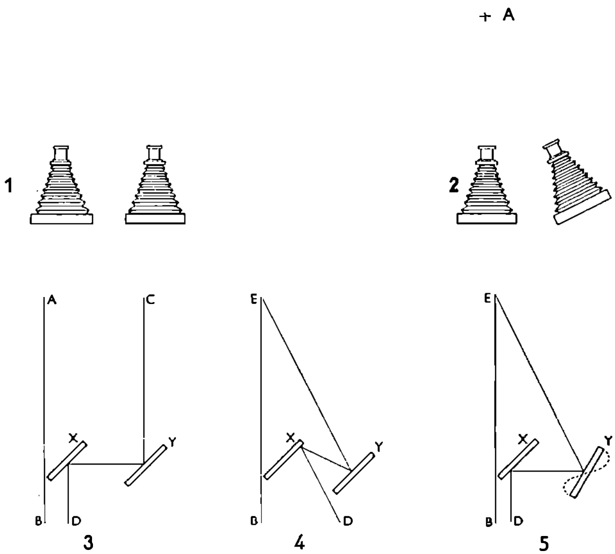


Fig. 38. Principle upon which Range-finders work.

1—Two cameras placed side by side with lenses parallel will take identical pictures of very distant objects.

2—When, however, the object is nearer and it is desired to have the object rendered centrally in each picture, the cameras have to be inclined towards one another. The angle of inclination and the distance between the cameras define the distance of the object.

3—In 3 AB and CD are rays proceeding from the same point of a distant object and passing centrally through the finder windows. AB is seen directly and CD after deviation by mirrors X and Y. The images coincide.

4—In 4 the object is nearer at E, the mirrors are in the same position as in 3, and the images are no longer coincident.

5—In 5 the mirror Y has been rotated to bring the images into coincidence, and the degree of rotation is a measure of the distance of E.

Range-finders. The estimation of distance is the first thing which the photographer is called upon to do, and many devices have been put upon the market and incorporated as parts of cameras to assist him to arrive at a correct result. In some models, range-finder and

view-finder are combined, and the combination may be coupled with the focussing mechanism.

Visual range-finders employ two windows some distance apart, through each of which an image of the object is obtained. Both pictures are viewed together, one directly and the other after deviation by a system of mirrors or prisms. If the second beam is directed through two successive right angles, and if the objects in the field of view are a long way away, the two fields will be identical. If they fall one upon another they will coincide exactly. If the system is a split-field one, then the two halves will link up. If the range-finder is directed at nearer objects the two fields will not be identical, but can be madc so by altering the degree of deviation of thc second beam. For a given distance between the windows the amount by which one beam must be redirected to bring the two images into coincidence is a measure of the distance of the object.

In many range-finders this variable deviation is brought about by altering the angle of a hinged mirror. The weakness is the coarseness of the adjustment—the complete range from three feet to infinity is represented by an angle of rotation of only 3°, and this small movement must be linked to a rotation of the focussing mount of 140°.

In certain Zeiss cameras, instead of the hinged mirror, two rotating wedges are used as in the diagram (Fig. 39). Here the range 0 to infinity is represented by a rotation through 90°.

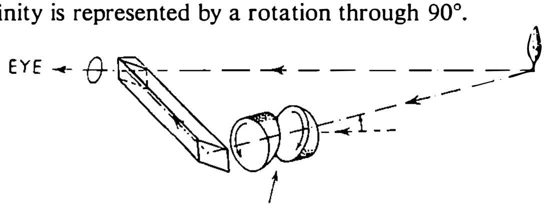


Fig. 39.

In the Contax models II and III the swing wedge principle is used and the range-finder is also a view-finder.

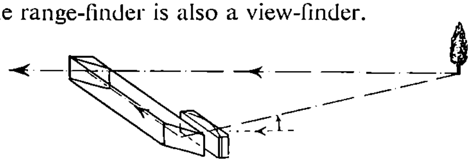


Fig. 40.

A further feature of these range-finders is the solid glass pencil which forms the range-finder base. Another very interesting range-finder is that embodied in the Kodak camera described on page 30.

The Shutter. The shutter is the most delicate part of the camera mechanism, and next to the lens, upon its quality and type the performance of the camera largely depends. In its simplest form it consists of a thin plate, which may be swung in front of, or away from,

the lens operating in close proximity to the diaphragm. For several reasons this is the ideal position for the shutter. In the first place the beam of light entering the camera is at its narrowest and the minimum shutter travel is required. Again, with the shutter in this position, the sensitive surface is evenly illuminated at all stages in the opening of the leaves. Diaphragm shutters of one type or another are, in fact, fitted to the great majority of cameras on the market to-day.

The next most important type of shutter is that which travels as nearly as may be in the focal-plane, and is therefore known by that name. In its simplest form this type of shutter consists of an opaque

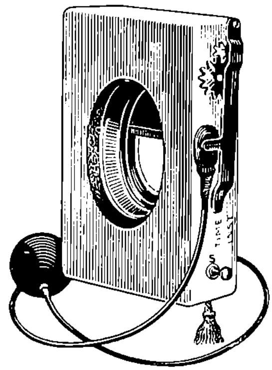


Fig. 41. Roller-blind shutter.

blind with a slit; the blind is driven past the front surface of the plate, and, as the slit passes across, the exposure is made. Advantages of the focal-plane shutter include high speeds and the freedom which it gives for the use of interchangeable lenses.

Diaphragm and focal-plane shutters are seldom used for stand cameras, since one of the former must be bought for every lens, whilst the focal-plane shutter requires to be built into the camera. For most stand-camera work there is no more reliable or convenient shutter than the roller-blind (Fig. 41), which can be fitted to lenses of various sizes by means of rubber adapting rings, and with many cameras may be fitted inside close behind the lens. Its maximum speed of about 1/80th sec. is sufficient for most subjects for which a stand camera is used, whilst, when set to "time," it is a perfect substitute for the inconvenient lens cap.

For studio cameras, where exposures shorter than about 1/10th sec. are never required, the most usual type of shutter is one consisting of two collapsible bellows, each forming half a hemisphere. These open under pneumatic or mechanical action and close again after an interval which can be regulated by the operator, the movement, as is necessary in portraiture, being practically noiseless.

A novel and very interesting type is the Louvre shutter fitted by the Williamson Manufacturing Co. Ltd. to aircraft cameras. In this shutter, slats like those in a Venetian blind open outwards through a right-angle and then reverse—speeds of from 1/50th sec. to 1/300th sec. being realizable. With this shutter there is no distortion, even at high aircraft speeds.

We must now consider the various types of shutter in greater detail, but first let us see what exactly is required of a good one. Its function is to expose the sensitive material to the action of light for a given time. A perfect shutter should expose each part of the plate equally, and preferably at the same time. It should make the most of the lens, *i.e.*, it should allow the whole cone of light passing through the selected aperture to fall upon the plate for the duration of the exposure. Finally, it should be silent in operation; there should be no jarring or vibration, and it should require no effort to set it in motion. Needless to say, the perfect shutter has not yet been realized in practice.

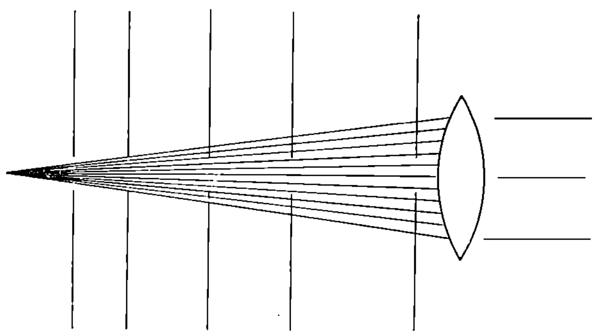


Fig. 42. Point source with focal-plane slit at different distances from sensitive material.

In diaphragm shutters the blade, or more generally blades, do not move instantaneously, and only for a part of the total duration of exposure is the shutter completely open. In the focal-plane type of shutter, successive portions of the sensitive surface are exposed during successive intervals of time. Assuming that the slit is in actual contact with the emulsion, a condition not realizable in practice, then at any stage in its travel all the light passing through the aperture and directed towards that part of the plate or film covered by the moving slit will be effective. In practice, the blind must be some way in front of the emulsion surface, and, from Fig. 42, it is obvious that the farther the slit is from the sensitive surface the less light reaches the plate. Again, one must bear in mind the fact that each part of the plate is allowed to see the light only for a fraction of the time taken by the slit to pass over the whole plate.

The efficiency of a shutter is defined as the ratio of effective exposure to the exposure theoretically possible if the plate were to receive all the light passing through the selected aperture for the entire duration of exposure.

We shall now consider the various types of shutter from the point of view of construction and of efficiency under working conditions.

In the cheaper box cameras on the market to-day, single-bladed diaphragm shutters having an elongated opening are sometimes employed, but in the majority of even moderately priced cameras the shutters are multi-bladed, the blades opening like the leaves of an iris. In the cheaper models the moving parts are actuated directly by variable spring tension; the spring is compressed by the movement of the exposure lever before it reaches the point at which release takes place; it is not possible to achieve high acceleration, and

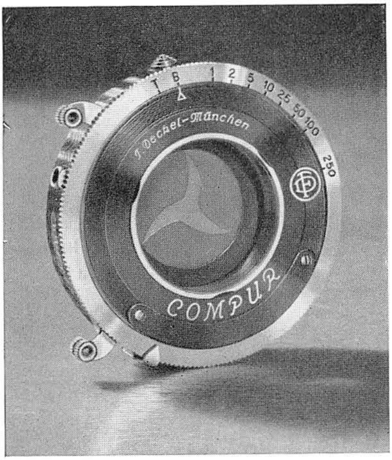


Fig. 43 COMPUR SHUTTER.

efficiencies are low. The more expensive models employ trains of gears in conjunction with spring tension, which may be constant or variable; the spring is pre-set, and for all but the highest speeds the leaves open with constant high velocity. For the lower speeds they remain open for a time, determined by the retarding gear train; for the highest speeds they close immediately full opening has been reached. Under such a system the efficiency obviously falls as the exposure time decreases, and rises as the lens is stopped down. As a result, the effective exposures at varying apertures are different from what one would expect from the relationship between the $f/$Nos.

The Newman pneumatic control is well known, and has proved very satisfactory in action. It may become sluggish if not used for

some time, but it has the merit of being very quiet in action, and no perceptible jar is communicated to the camera.

One of the most popular shutters of the diaphragm type is the Compur. In one model, speeds from 1 second to 1/500th of a second are available, the slower speeds being gear controlled, the intermediate ones having no retardation and the higher speeds being achieved by means of a subsidiary spring.

As already mentioned, the simplest focal plane shutter consists of a blind with a single slit. An advance on this type is the blind with a number of slits of different width. Yet another development is the double blind, in which the separation between the blinds constitutes a slit of variable width. Both multi-slit and double-blind types are in use to-day, and in both types the driving spring tension may be constant or variable. Generally speaking, the blinds are self capping, *i.e.*, the slit is covered while the shutter is being set.

As we have seen with focal plane shutters, different parts of the plate are exposed at different times, and with fast moving objects (or, as in aerial work, when the camera is in rapid motion) distortion may result, and it will vary according to the relationship between direction of movement of blind and object.

The miniature cameras, Contax and Leica, are fitted with focal-plane shutters of the double-blind type. In the Contax the blind travels vertically when the camera is held normally—in the Leica it travels from side to side, and the slit width widens as it crosses the film to compensate for acceleration.

With focal-plane shutters, duration of exposure is taken to be the time for which any one part of the emulsion is exposed, *i.e.*, it is the time taken for the slit to pass a given point. This statement needs further amplification, however, because for a given slit width and time of travel, the actual *duration* of exposure is dependent on the distance between slit and emulsion surface, the exposure time being greater the greater the distance. Duration is also increased by opening up the stop. The efficiency of such a shutter depends, as we have seen, on how close the blind is to the film, being greater as the distance lessens. Efficiency also increases with increase in slit width and with reduction in lens aperture.

It is worthy of note that, where constant spring tension is employed, moving objects may be rendered sharply by giving shorter exposures, obtained by narrowing the slit, but distortion cannot be reduced by this method. It is constant for a given time of travel of the slit.

The Diaphragm. The simplest diaphragm consists of a disc bearing a number of circular openings and capable of rotation, so that any one of the openings may be brought into position in line with the lens. Such an arrangement is obviously limited in scope, and all the better cameras are now fitted with iris diaphragms, the leaves of which are arranged to open, leaving a circular aperture, whose diameter is continuously variable. Where the camera shutter is of

the diaphragm type the diaphragm itself is part of the shutter assembly.

It may be of interest to note that, assuming a perfect lens with the diapl ·agm placed exactly at the optical centre, there would be no real need for the aperture to be placed centrally with regard to the lens. For instance, a single blade pivoted close to the lens in such a way that it could be swung completely aside or brought over by degrees to obstruct more and more of the beam passing through the lens would act equally well. Because each part of the perfect lens has an equal share in the formation of each part of the image, illumination would remain even all over whatever the position of the obstructing plate. In practice, of course, the best part of a lens is the central portion, and so the central opening diaphragm is universally adopted.

The Lens-hood. Relatively few people trouble to use a lens-hood, and yet in a great many instances its employment would result in greatly improved pictures. It should form a part of the equipment of every photographer, and should certainly be used in all cases where it is necessary or desirable to make exposures with the sun or other bright source of light in such a position that it may reach the unprotected camera lens directly. Even if such light does not cause flare spots upon the film, it may produce a general flattening of the pictures with loss of definition.

Care should, of course, be taken when fitting a lens-hood that it does not mask the edges of the picture. Difficulty is sometimes experienced when it is desired to use the lens-hood in conjunction with a colour filter. The best practice is to obtain the filter in the modern type of mount, in which the front portion is reduced to have an outside diameter equal to that of the lens mount itself. The lens-hood can then be fixed in position upon the filter mount.

Colour filters will be fully discussed in a later section.

Tripods. For all exposures longer than 1/25th second, or those of 1/50th second in the case of miniature cameras, it is necessary to rest the camera upon a rigid support. Many makeshift stands may be brought into service on occasion, but when such exposures are to be commonly made, a tripod is essential. Tripods may be obtained in wood or metal. In the former case the legs are separately detachable and collapsible, and in the latter they are normally telescopic. The essential feature of a tripod is rigidity, and in very many cases this is sacrificed to make for lightness and compactness. The golden rule is: Buy a heavy tripod.

MODERN FILM CAMERAS

The following is a list of some of the popular roll and miniature film cameras, with a brief description of their more important features. For information concerning plate cameras, readers are advised to consult the catalogues of the principal manufacturers.

CAMERA	FEATURES	LENSES AVAILABLE	SHUTTERS AVAILABLE AND SHUTTER SPEEDS	VIEW-FINDER
BALDINA	Automatic counter. Takes standard cassettes of 35 mm. film	$f/4{\cdot}5$	Prontor II to 1/200. T. and B.	Optical
CONTAFLEX	Reflex camera. Built-in photo-electric exposure meter. Automatic film transport on setting shutter. Automatic counter. Takes standard cassette or Contax daylight spool of 35 mm. film	Wide range of interchangeable lenses including $f/1{\cdot}5$, $f/2$, $f/2{\cdot}8$	Focal-plane ½ to 1/1,250	Optical and range-finder
CONTAX	Automatic film transport on setting shutter. Automatic counter. Contax III has built-in photo-electric exposure meter. Takes standard cassettes of 35 mm. film or Contax daylight loading spool. Wide range of accessories. Plate back available	Wide range of interchangeable lenses including $f/1{\cdot}5$, $f/2$, $f/2{\cdot}8$, $f/3{\cdot}5$	Focal-plane ½ to 1/1,250	Coupled built-in range-finder
DOLLINA	Automatic film transport on setting shutter and locking device. Takes standard cassettes of 35 mm. film	$f/2{\cdot}9$, $f/4{\cdot}5$	Compur to 1/300. T. and B.	Optical. Models II and III have coupled range-finder
KARAT	Special 12-exposure cassettes of 35 mm. film. Requires one for take up side	$f/3{\cdot}5$, $f/6{\cdot}3$	Automat 1/25, 1/50, 1/100. T. and B. Compur-Rapid. 1 to 1/500 T. and B.	Optical
KINE EXAKTA	Film cutter incorporated for removing partly exposed film. Automatic film transport on setting shutter. Takes standard cassette of 35 mm. film	Interchangeable lenses	Focal-plane up to 1/1,000	Special focussing screen. Single lens reflex
KORELLE K.	Takes 100 frames (18×24 mm.) on 35 mm. film loaded in standard cassettes, also takes Contax spool. Film locking device	Interchangeable lenses	Compur to 1/300 T. and B.	Optical
LEICA	Wide range of accessories. Automatic film transport on setting shutter. Takes standard cassettes of 35 mm. film	Wide range of interchangeable lenses including $f/1{\cdot}5$	Focal-plane 1/20 to 1/500 and T. Model 3b focal-plane to 1/1,000	Optical. Models 2 and 3b, optical and coincidence range-finder

CAMERA	FEATURES	LENSES AVAILABLE	SHUTTERS AVAILABLE AND SHUTTER SPEEDS	VIEW-FINDER
NETTAX	Takes standard cassettes of 35 mm. film. Automatic film transport on setting shutter	Interchangeable lenses	Focal-plane 1/5 to 1/1,000	Coupled wedge type range-finder
RETINA	Takes standard cassettes of 35 mm. film. Film locking device	f/2, f/2·8, f/3·5	Compur to 1/300 T. and B. Compur Rapid to 1/500 T. and B.	Optical and direct vision coupled range-finder
ROBOT	Pressure of release button takes picture; winds film; counts; sets shutter. Photographs can be taken as fast as release can be pressed. Takes special cassettes giving 50 pictures 24×24 mm. on 35 mm. film	Interchangeable lenses	Patent disc 1/500	Automatic zone focussing supersedes range-finder
SUPER BALDINA	Takes standard cassettes of 35 mm. film. Film locking device. Automatic counting. Parallax compensation	f/2, f/2·8, f/2·9	Compur to 1/250 T. and B. Compur Rapid to 1/500 T. and B.	Optical
SUPER DOLLINA	Takes standard cassettes of 35 mm. film. Film locking device. Parallax compensation	f/2, f/2·8	Compur to 1/300 T. and B. Compur Rapid to 1/500 T. and B.	Optical and coupled range-finder
SUPER NETTEL	Takes standard cassettes of 35 mm. film	f/3·5	Metal focal-plane shutter to 1/1,000	Optical and range-finder
TENAX	Takes standard cassettes of 35 mm. film. Single movement shutter setting and film winding for quick action shots	f/2, f/2·8	Compur Rapid to 1/400 T. and B.	Optical and range-finder
WELTI	Takes standard cassettes of 35 mm. film	f/2·8, f/3·5	Compur to 1/300 T. and B. Compur Rapid to 1/500 T. and B.	Direct vision
WELTINI	Takes standard cassettes of 35 mm. film. Film locking device	f/2, f/2·8, f/3·5	Compur Rapid to 1/500 T. and B.	Optical and range-finder
AUTOLETTE	Takes standard No. 27 size roll film	f/3·5	Prontor II, 1–1/175 T. and B.	Direct frame

CAMERA	FEATURES	LENSES AVAILABLE	SHUTTERS AVAILABLE AND SHUTTER SPEEDS	VIEW-FINDER
BABY BOX TENGOR	Takes standard No. 27 size roll film	*f*/11	T. and I. shutter	Direct frame
BABY SIBYL	Takes standard No. 27 size roll film. A plate and film pack camera is available	Choice of lenses	N. and G. shutter $\frac{1}{2}$–1/150	Brilliant finder
BALDI	Parallax compensation. Takes standard No. 27 size roll film	*f*/2·9, *f*/4·5	Compur to 1/300 T. and B. Compur Rapid to 1/500 T. and B.	Optical
DOLLY Model A	Takes standard No. 27 size roll film	*f*/3·5, *f*/4·5	Compur to 1/300 T. and B.	Direct vision optical finder
ENSIGN MULTEX II	Automatic film transport on setting shutter. Takes standard No. 27 size roll film	Interchangeable lenses	Focal-plane to 1/1,000 and T.	Optical and range-finder
EXAKTA	Automatic film transport on setting shutter. Takes standard No. 27 size roll film. Model C has back enabling focussing screen and plates to be used	Interchangeable lenses, wide selection	Focal-plane 1/25–1/1,000 T. and B.	Optical and range-finder
FOTH DERBY	Takes standard No. 27 size roll film	*f*/2·5, *f*/2·8, *f*/3·5	Focal-plane 1/25–1/500 and B.	Optical and direct vision
GOLDI	Takes standard No. 27 size roll film	*f*/2·9, *f*/4·5	3 and 4 speed shutters. Compur to 1/300 T. and B.	Optical and direct vision
KODAK BABY BROWNIE	Moulded plastic construction. Fixed focus. Takes No. 27 size roll film	Meniscus	Snap only	Direct vision frame
PARVOLA	Takes standard No. 27 size roll film. Automatic film locking device	*f*/4·5	Compur Rapid 1–1/500 T. and B.	Direct frame
PURMA	Takes standard No. 27 size roll film	*f*/6·3	Focal-plane to 1/450	Built-in optical

CAMERA	FEATURES	LENSES AVAILABLE	SHUTTERS AVAILABLE AND SHUTTER SPEEDS	VIEW-FINDER
ROLLEIFLEX	Takes standard No. 20 size roll film. Automatic film wind Sports Model takes standard No. 27 size roll film	f/3·5 f/2·8, f/3·5	Compur Rapid to 1/500 T. and B.	Direct vision-finder Reflex camera
WESTEX MINIATURE	Takes standard No. 27 size roll film	f/2·9	Prontor II to 1/175 T. and B.	Optical
ALTIFLEX	Takes standard No. 20 size roll film	f/2·9, f/3·5, f/4·5	Automat 1/25–1/100 Prontor II, 1–1/175 T. and B. Compur to 1/300 T. and B.	Reflex camera
AUTO-ROLLEIFLEX	Takes standard No. 20 size roll film. Completely automatic film wind. Film locking device	f/2·8, f/3·5	Compur to 1/300 T. and B. Compur Rapid to 1/500 T. and B.	Finder-lens Reflex camera
BALDAX	Takes standard No. 20 size roll film	f/2·9, f/4·5	Compur to 1/300 T. and B. Compur Rapid to 1/500 T. and B.	Optical
BALDAXETTE II	Automatic film transport. Takes standard No. 20 size roll film	f/2·9	Compur to 1/250 T. and B.	Direct vision parallax correcting view-finder, coupled range-finder
BOX TENGOR	Takes standard No. 20 size roll film	f/11 (supplementary lens for portraits; two for close ups)	Special B. and 1/25	Direct vision frame and reflecting
ENSIGN ALL DISTANCE 20	Takes standard No. 20 size roll film	Ensign all distance	T. and I.	Direct vision frame and reflecting
ENSIGN POCKET 20	Takes standard No. 20 size roll film	Meniscus Anastigmat f/8·5	T., B., and I.	Brilliant view-finder

CAMERA	FEATURES	LENSES AVAILABLE	SHUTTERS AVAILABLE AND SHUTTER SPEEDS	VIEW-FINDER
ENSIGN AUTORANGE 20	Takes standard No. 20 size roll film	$f/3{\cdot}8$, $f/4{\cdot}5$	Mulchro 1/100 T. and B. Prontor II to 1/150 T. and B. Compur to 1/250 T. and B. Compur Rapid to 1/400 T. and B. Also available with focal-plane shutter	Brilliant and optical direct vision
ENSIGN AUTORANGE 220	Takes standard No. 20 size roll film	$f/2{\cdot}8$, $f/3{\cdot}5$, $f/4{\cdot}5$	Prontor I, 1/25-1/125 T. and B. Prontor II to 1/150 T. and B. Compur to 1/150 T. and B. Compur Rapid to 1/400 T. and B.	Optical and coupled range-finder
ENSIGN SELFIX 20	Takes standard No. 20 size roll film	$f/4{\cdot}5$ to $f/7{\cdot}7$	3-speed Trichro. T. and B. 7-speed Mulchro. T. and B. Prontor I to 1/125 T. and B. Prontor II to 1/150 T. and B. Compur to 1/250 T. and B.	Optical direct vision
ENSIGN SELFIX 220	Takes standard No. 20 size roll film	$f/3{\cdot}5$, $f/4{\cdot}5$, $f/6{\cdot}3$, $f/7{\cdot}7$	Ensign 1/25, 1/50, 1/100. Prontor I, 1/25-1/125 T. and B. Prontor II to 1/150 T. and B. Compur to 1/150 T. and B.	Optical
FOTH FLEX	Takes standard No. 20 size roll film	$f/3{\cdot}5$	Focal-plane 2 sec. to 1/500 and B.	Reflex camera
IKONTA	Film locking device preventing double exposure. Takes standard No. 20 size roll film	$f/3{\cdot}5$, $f/4{\cdot}5$	Compur to 1/300 T. and B. Compur Rapid to 1/500 T. and B.	Optical

CAMERA	FEATURES	LENSES AVAILABLE	SHUTTERS AVAILABLE AND SHUTTER SPEEDS	VIEW-FINDER
IKOFLEX II	Pluro convex focussing screen. Automatic depth of focus scale. Takes standard No. 20 size roll film	f/3·5	Compur to 1/300 T. and B. Compur Rapid to 1/500 T. and B.	Mirror. Reflex camera
IKOFLEX III	Similar construction to Ikoflex II. Double exposure prevention device. Takes standard No. 20 size roll film	f/3·5	Compur to 1/300 T. and B. Compur Rapid to 1/500 T. and B.	Mirror. Reflex camera
ISORETTE	Takes standard No. 20 size roll film	f/4·5, f/6·3	Vario 1/25, 1/50, 1/100, T. and B. Compur to 1/300 T. and B.	Optical
KODAK JUNIOR SIX-20	Revolving focus adjustment. Takes Z.20 size roll film	f/6·3, f/11	3-speed to 1/100	Reflecting
KODAK JUNIOR SIX-20 DE-LUXE	Similar features to Kodak Junior Six-20. Takes Z.20 size roll film	f/4·5	Drakmar 4-speeds to 1/100	Direct vision and reflecting
KODAK SPECIAL SIX-20	Revolving focus 3½ ft. to Inf. Takes Z.20 size roll film	f/4·5	Compur Rapid to 1/400 T. and B.	Optical and direct vision
KODAK DUO SIX-20	Takes Z.20 size roll film	f/3·5, f/4·5	Kodak 4-speeds to 1/125. Compur to 1/300 T. and B.	Optical and direct vision
KODAK JIFFY SIX-20	Two focus positions 5 ft. to 10 ft. Takes Z.20 size roll film	Twindar 3 apertures	Snap and T.	Reflecting
KODAK BROWNIE POPULAR	Box camera. Fixed focus. Takes Z.20 size roll film	Meniscus	Snap and T.	Reflecting
KODAK BROWNIE SENIOR	Fixed focus box camera. Takes Z.20 size roll film	Meniscus	Snap and T.	Reflecting

CAMERA	FEATURES	LENSES AVAILABLE	SHUTTERS AVAILABLE AND SHUTTER SPEEDS	VIEW-FINDER
KODAK PORTRAIT BROWNIE	Fixed focus box camera. Portrait attachment. Takes Z.20 size roll film	Meniscus	Snap and T.	Reflecting
KODAK FOLDING BROWNIE	Fixed focus. Takes Z.20 size roll film	Meniscus	Snap, T. and B.	Direct vision and reflecting
MINNY	Focussing returns to infinity on closing camera. Takes standard No. 20 size roll film	f/2·9	Compur to 1/300 T. and B.	Optical split-field range-finder
NETTAR	Various models. Takes standard No. 20 size roll film	f/3·5, f/4·5, f/6·3, f/7·7	Derval 1/25, 1/50, 1/100, T. and B. Telma to 1/125, T. and B. Automat 1/25, 1/75, T. and B. Klio 1–1/175, T. and B.	Model 510, Optical. Model 510/2, brilliant finder and direct vision frame
PILOT 6	Single lens reflex. Takes standard No. 20 size roll film	f/2·9, f/3·5, f/4·5	Special metal type to 1/200 T. and B.	Reflex camera. Direct vision frame finder
PRIMARFLEX	Single lens reflex. Spring raised mirror automatically set together with shutter when film is wound. Takes standard No. 20 size roll film	Interchangeable lenses	Focal-plane shutter 1–1/1,000	Mirror. Reflex camera
REFLEX-KORELLE	Coupled film and shutter wind. Magnifier for critical focussing. Takes standard No. 20 size roll film	Interchangeable lenses	Focal-plane R.K. (1a) 1/25–1/500. R.K. (2a) 2–1/500	Reflex and direct vision
ROLLEICORD	Takes standard No. 20 size roll film	f/3·5, f/4·5	Compur to 1/300 T. and B.	Finder-lens. Reflex Camera
ROLL OP.	Takes standard No. 20 size roll film	f/2·8	Compur Rapid to 1/400 T. and B.	Optical. Coupled range-finder
SPEEDEX CLACK	Model 74 has built-in portrait attachment. Takes standard No. 20 size roll film	f/8·8, f/11	T. and I.	Brilliant finders

CAMERA	FEATURES	LENSES AVAILABLE	SHUTTERS AVAILABLE AND SHUTTER SPEEDS	VIEW-FINDER
SUPER SPORT DOLLY	Takes standard No. 20 size roll film and also plates. One model has built-in exposure meter	f/2·8, f/2·9	Compur to 1/300 T. and B. Compur Rapid to 1/400 T. and B.	Optical and coupled range-finder
SUPER IKONTA	Focussing by rotating wedge. Film locking device preventing double exposure. Takes standard No. 20 size roll film	f/3·5, f/4·5	Compur to 1/250 T. and B. Compur Rapid to 1/400 T. and B.	Optical and range-finder. Model 532/16 has combined field and range-finder
SUPERB	Takes standard No. 20 size roll film	f/3·5	Compur to 1/250 T. and B.	Reflex camera
VAUXHALL DE-LUXE	Takes standard No. 20 size roll film	f/2·9	Compur to 1/250 T. and B.	Optical direct vision finder
VAUXHALL RANGE-FINDER	Automatic return to infinity position when closing camera. Takes standard No. 20 size roll film	f/2·9	Compur to 1/250 T. and B.	Optical and range-finder
WELTAX DE-LUXE	Takes standard No. 20 size roll film	f/2·9	Compur to 1/250 T. and B. Compur Rapid to 1/500 T. and B.	Masked optical coupled range-finder Parallax adjustment
WELTUR	Takes standard No. 20 size roll film	f/2·8	Compur to 1/250 T. and B. Compur Rapid to 1/500 T. and B.	Optical
WESTEX SENIOR and SUPER WESTEX	Takes standard No. 20 size roll film	f/2·9	Compur to 1/250 T. and B.	Optical
WESTMINSTER VICTORIA	Takes standard No. 20 size roll film	f/2·9	Prontor to 1/150	Optical
XCEL	Box camera. Takes standard No. 20 size roll film	Single lens	T. and I.	Brilliant view-finder

CAMERA	FEATURES	LENSES AVAILABLE	SHUTTERS AVAILABLE AND SHUTTER SPEEDS	VIEW-FINDER
ZECA FLEX	Twin lens reflex in which the camera but not the finder folds. Takes standard No. 20 size roll film	$f/3{\cdot}5$	Compur 1/250 T. and B. Compur Rapid 1/400 T. and B.	Reflex camera
VOIGTLANDER BRILLIANT	Built-in filters. Automatic stop film wind. Takes Z.20 size roll film	$f/3{\cdot}5$ to $f/7{\cdot}7$	Singlo to 1/75. Prontor to 1/175 T. and B. Compur to 1/300 T. and B. Compur Rapid to 1/500 T. and B.	Direct vision
VOIGTLANDER OPTICAL BESSA	Automatic cover to windows. Takes Z.20 size roll film	$f/3{\cdot}5$ to $f/7{\cdot}7$	Singlo to 1/75. Prontor to 1/125 T. and B. Prontor to 1/150 T. and B. Compur to 1/250 T. and B. Compur Rapid to 1/400 T. and B.	Optical
VOIGTLANDER RANGE-FINDER BESSA	Hinged filter in interchangeable mount. Takes Z.20 size roll film	$f/3{\cdot}5$	Compur Rapid to 1/400 T. and B.	Optical and range-finder
VOIGTLANDER SUPERB	Correction for parallax. Takes Z.20 size roll film	$f/3{\cdot}5$	Compur to 1/250 T. and B.	Optical

CHAPTER III

THE RECORDING MEDIUM

In the manufacture of sensitized photographic materials, reliance is placed almost entirely upon the light sensitivity of the silver halides, *i.e.*, of the salts of silver with the group of elements known as the halogens-bromine, chlorine, iodine. Materials designed for the production of the original negative are coated with suspensions of minute crystals of silver bromide in gelatin, in which small quantities of iodide are also normally present. In positive emulsions the sensitive material may be silver bromide alone or in company with silver chloride, or it may be silver chloride alone.

Silver halide emulsions are of two types. In the first the action of light produces the final silver image directly—in the second a latent image is formed by light, and the real visible image is produced by the action of the developer. All negative emulsions, and most modern positive emulsions, are of the second type. In this section we will deal more specifically with negative emulsions, although much of what follows will be applicable to positive emulsions also.

In recent years great progress has been made in the production of new and fast emulsions—a direct result of the policy adopted by all the leading manufacturers of maintaining large and well equipped research establishments which work in close association with the production units. Each firm has developed its own particular methods, many of which are naturally regarded as confidential. The general principles on which emulsion making rest are, however, well established, and these will at least serve to illustrate the complexity of the whole process.

The principal materials used in the preparation of the emulsion comprise silver nitrate, alkali halides and gelatin, and all these must satisfy stringent tests. The gelatin must be specially carefully chosen, since it is not a simple chemical but a complex mixture of substances obtained from the hides and tendons of animals, and although silver salts form the actual sensitive material, the gelatin plays a very important part both physically and chemically.

Its first advantage is that no expensive solvents are required. Dispersed with water, gelatin forms a convenient medium in which the silver nitrate and the alkali halides are brought together, and in which the insoluble silver halides produced remain suspended in a fine state of division. Further, by cooling an aqueous solution of gelatin it can be set to a firm jelly, and so it is possible to cause the emulsion to set firmly almost immediately after it has been applied to the base. Thereafter all that remains to be done is to remove the bulk of the water in a current of warm air, and the resulting emulsion surface is reasonably strong and resistant to abrasion. Chemically, the gelatin acts in various ways. By reason of certain of its con-

stituents it acts as a sensitizer and it is also believed to act as a bromine acceptor. The action of light predisposes the silver halide grain to break down to silver with the liberation of bromine. Development simply causes the breakdown to proceed in the places where it has begun. After exposure, and before development, there is a tendency for the light-separated silver and bromine to re-combine —in other words, for the effect of the exposure to be to some extent undone. By combining with the liberated bromine, gelatin prevents this back reaction and so enables full use of the exposure to be made.

To return to the process of emulsion-making, silver nitrate and alkali bromide are caused to react in aqueous gelatin to form silver bromide. After the reaction is complete, the emulsion is subjected to various treatments designed to increase the sensitivity of the silver halide grains. At a certain stage the emulsion is cooled and caused to set to a jelly. It is then broken up by means of a shredder and the soluble salts are removed by washing. Next it is remelted, various additions are made—it undergoes a further period of heating at a prescribed temperature, and final additions are made.

The silver halides themselves are only sensitive to the radiations at the blue end of the spectrum, but, by the addition of certain dyes, the sensitivity can be extended right throughout the visible spectrum (4,000 Å to 7,600 Å) and to the invisible infra-red beyond. Where the production of the negative is concerned and the object is the production of a correct representation in monochrome of a coloured subject, colour sensitive emulsions are always used. When it is necessary to modify the tone relationships between differently coloured parts of the subject, full control can be exercised by the use of fully colour sensitive materials (panchromatic) in conjunction with filters.

The extent to which an emulsion has been dye-sensitized makes a very considerable difference to the amount and quality of light which is permissible during manufacture and in subsequent use.

The constitution of the latent image, and the manner in which it is formed, have provided many intriguing problems for research workers. Very recently a new approach has been made by way of quantum mechanics, first by Webb and then by Gurney and Mott, with particularly fruitful results. According to the theory advanced by Gurney and Mott, the first action of light is to set free electrons from the halide ions. These electrons can move freely about in the silver halide crystals, but as soon as they come into contact either with silver or silver sulphide their mobility ceases. The electrons link up with the silver or silver sulphide, causing it to become negatively charged and to attract silver ions in thermal motion within the crystal lattice. When the aggregation of silver becomes sufficiently great, development can occur.

The silver sulphide and silver which form the original centres occur as "sensitivity specks" on and within the silver halide

grains, and have their origin in the complex chemical reactions which take place during the making of the emulsion.

This theory explains development in a similar fashion—the developer gives up electrons which are trapped at the silver aggregate, causing it to attract more silver from the silver bromide.

Other things being equal, sensitivity increases with grain size. In a normal emulsion the larger grains contain a greater proportion of iodide, but whether this should be held responsible for the greater sensitivity is not known.

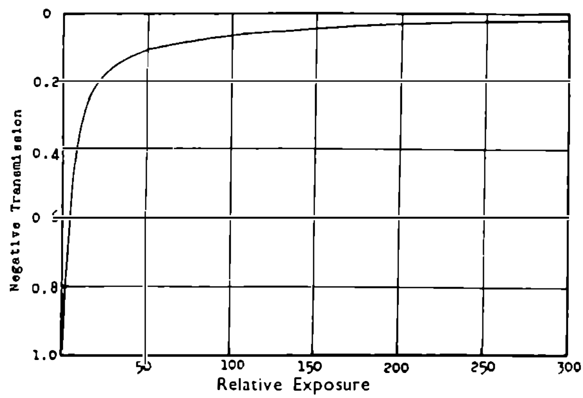


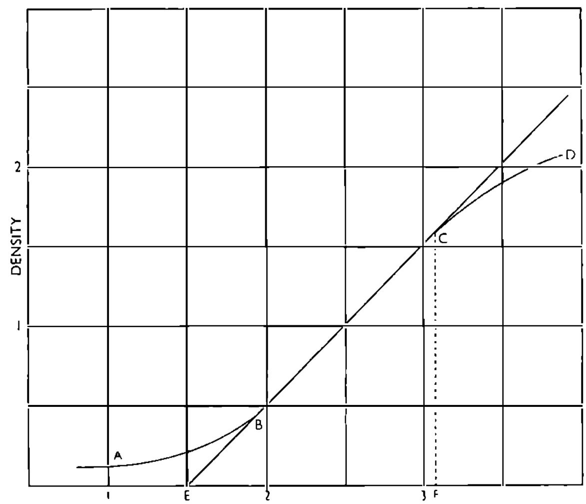
Fig. 44

The reproduction curve of a typical negative material in which transmission is plotted against relative subject brightness. The transmission scale is "upside-down" because we want to show the effect of increased exposure increasing upwards, and a small exposure results in a high transmission.

It is important to realize that when a plate or film is exposed in a camera, different parts of the sensitive surface receive different "exposures" or different amounts of light energy according to the brightnesses of the different parts of the image. Since size and sensitivity are connected, it follows that the response of an emulsion to a range of light intensities will depend to some extent at least on the size distribution of its constituent grains. This is observed in practice—process materials which are normally of a contrasty type have a limited range of grain sizes—soft gradation portrait materials have a wide range of grain sizes. The general response of a photographic material to light is shown by the characteristic curve in which density of developed deposit is plotted against the logarithm of the exposure producing it, and since each characteristic curve represents one development time the complete behaviour of the emulsion is shown by a family of curves.

The logarithm of an exposure has been referred to and as it will be seen in a moment, density is itself a logarithmic function, so before proceeding further it is necessary to define the terms and see just why they are used.

Every number may be expressed in terms of another given number (*e.g.*, 10) raised to a certain power. Thus 100 is 10^2, 1,000 is 10^3, and 10,000 is 10^4 and so on. The particular power to which the basic number must be raised is the logarithm of the number in question—



Relative Log Exposure.

Fig. 45.

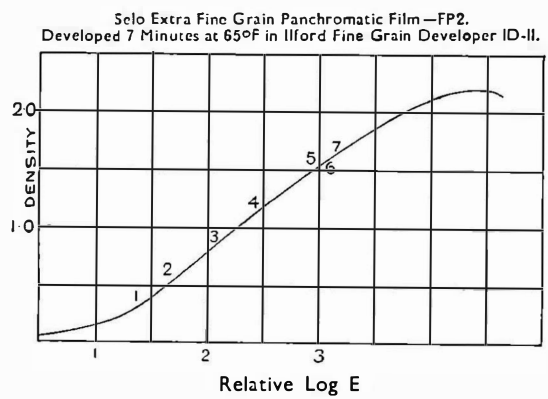
The Characteristic Curve.

A–B is the "toe" or "under-exposure" region
B–C is the "straight line" region
C–D is the "over-exposure" region

$\frac{FC}{EF}$ = tan CEF = gamma

thus 2 is the logarithm of 100 and 3 is the logarithm of 1,000. A complete table of logarithms presents a simple means of carrying out quite involved calculations very easily, because by their aid multiplication is reduced to addition and division to subtraction. Simple algebra teaches that $10^x \times 10^y = 10^{x+y}$ and that $10^x/10^y = 10^{x-y}$.

The product of any two numbers can therefore be expressed in terms of the basic number raised to a power equal to the sum of the logarithms of the individual numbers. By referring backwards from the table of logarithms to the corresponding numbers, the required product is obtained directly. Similarly for division.



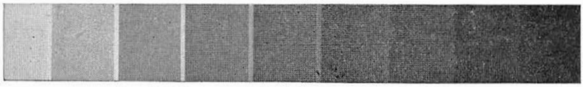


Fig. 46. In the picture negative the image is composed of developed silver, the density in any area depending upon the brightness of the corresponding part of the subject. It would be possible to construct the characteristic curve of any emulsion or at least a part of it from a picture negative, given the brightnesses of the various parts of the subject and the time of exposure. In the above picture the densities have been measured in the parts indicated by figures and the values obtained are shown below plotted in the form of a characteristic curve. Normally, however, a standard negative is produced by giving a known range of exposures to the plate or film under test.

It is easy to see that for a series of numbers in geometric progression, *i.e.*, in which each member is obtained by multiplying the number preceding by a constant figure, the corresponding logarithms

are in arithmetic progression, *i.e.*, each is arrived at by adding a constant amount to the preceding number.

Thus for numbers	**10**	**100**	**1000**	**10,000**
the corresponding		**(10× 10)**	**(10 × 100)**	**(10× 1000)**
logarithms are	**1**	**2**	**3**	**4**

In other words, by constructing a logarithmic scale it is possible to represent equal multiples by equal increments.

It is true that it is not necessary to use logarithmic scales to illustrate the nature of the response of the photographic emulsion—exposure could be plotted against negative transmission (the ratio

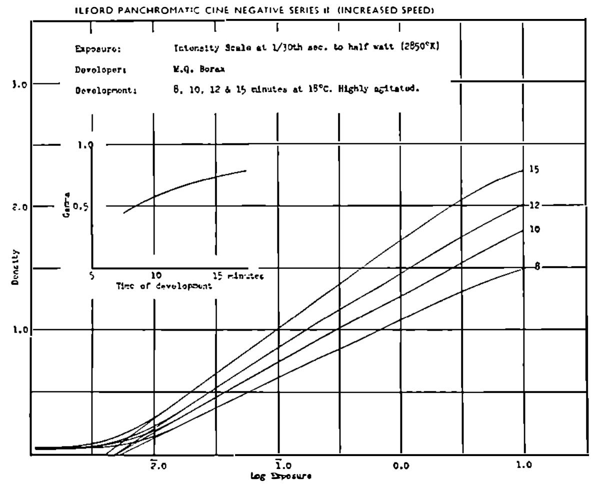


Fig. 47

Family of curves obtained with one developer but with different development times. The slope of the curve (gamma) is seen to increase, and in the inset gamma is plotted against time of development.

of light transmitted by the film to light incident upon it) to get a curve like that in Fig. 44. The curve of density against the logarithm of exposure has, however, many advantages.

In a great range of light intensities, say 1,000 to 1 for the curve to bc informative, particularly about the low intensities, it would be necessary to plot exposure on a fairly large scale and to have a big picture. It is possible to go further and say that the eye sets as much store by a two-to-one change in low intensities as it does in a two-to-one change in high intensities—in other words, two brightness differences appear the same to the eye if the separate brightness ratios are the same in each case. This state of affairs is accurately represented if brightness (or exposure) is represented on a logarithmic scale, for then a two-to-one change is represented by a fixed

increment. This means that the logarithmic representation puts the response of the plate or film into correct perspective.

What holds good for brightness and exposure holds good for the representation of the photographic effect which is usually expressed in terms of image density.

What is meant by Density? The density of an image is a measure of its light-stopping power in logarithmic terms. If *Io* is the intensity of light incident on the plate or film and *It* the intensity of light transmitted, then $\frac{It}{Io}$ is the fraction transmitted, $\frac{Io}{It}$ is the opacity, and the logarithm of opacity is the density. Hurter and Driffield proved that density is proportional to the mass of silver developed per unit area, and on the further work of these two pioneers has been built the whole structure of sensitometry—the accurate measurement and interpretation of the response of the photographic emulsion to light.

If a parallel beam of light falls upon a silver image, part is absorbed and part is scattered, and the value of the density assigned to the deposit depends on how much of the scattered light is measured. *Dp* "parallel" represents the density when only parallel light leaving the film is measured. *Dd* "diffuse" represents the density when all the light leaving the film is measured.

Dd is a fair measure of printing density in contact printing, but in enlarging *Dp* is a nearer approximation to the true value. $\frac{Dp}{Dd}$ is known as the Callier co-efficient. The factor varies according to the emulsion. *Dp* is always greater than *Dd*, the difference being dependent upon the amount of scatter of the emulsion. Broadly speaking, the more closely the ratio approximates to unity the finer is the grain of the emulsion.

Densities are conveniently measured by means of a photo-electric density meter designed in the Laboratories of the British Photographic Research Association and constructed by Messrs. W. Watson & Sons Ltd. With this apparatus a single observer can measure in a normal day's working about 1,000 opacities with values between 1 and 10,000. There is no eye-strain, and the personal element is completely eliminated. By means of a mechanical attachment, results are plotted directly on graph paper so that characteristic curves are immediately available.

As Hurter and Driffield pointed out, the complete response of an emulsion to light can only be expressed by a curve or series of curves relating densities developed under given conditions to the logarithms of the exposures producing them. Curves for different emulsions may run parallel, diverge or cross, from which it is evident why any one number must fail to be indicative of the behaviour of any emulsion.

The production of these curves is, of course, a routine in all photographic manufacturers' laboratories. By means of a sensitometer a graded series of exposures is given to the strip of plate, or film under test, the exposures mounting logarithmically in steps along its length. This strip is developed under standard conditions, fixed, washed, and dried, and then the densities are read. All this involves careful work and the use of elaborate apparatus. The exposures must be accurately known, and the light source producing them must be of standard intensity and colour quality. Many sources have been proposed and used at various times. The International Congress of Photography held at Dresden in 1931 ratified

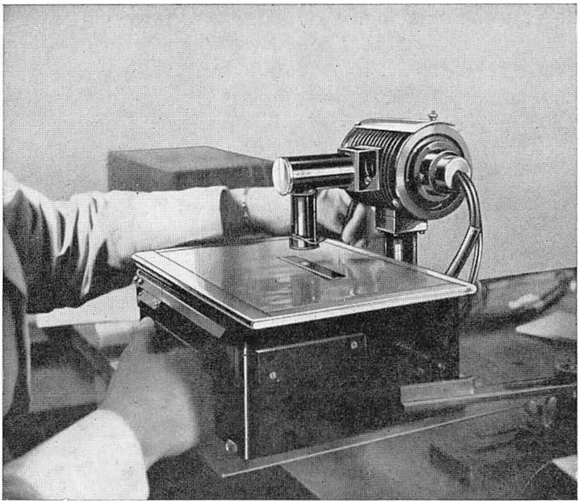


Fig. 48 PHOTO-ELECTRIC DENSITOMETER.

the proposals put forward at an earlier Congress to adopt the Tungsten lamp operating at a colour temperature of 2360°K. screened with a Davis Gibson filter as daylight standard for negative materials. This quality of light is taken to be that of mean noon sunlight at Washington.

To produce the graded series of exposures, it is possible to alter either the intensity of illumination or the time for which the exposure lasts. These systems will not necessarily give the same results, and, to obtain sensitometric data which will correctly indicate the behaviour of the material under the conditions of use, the exposures and intensities should be comparable with those which the material is designed to receive in practice.

The developer and its constituents must be borne in mind when characteristic curves are compared, and sensitometric data should be obtained in every case with the developer which is going to be used in practice. The temperature of the developer must be carefully controlled. Agitation is necessary, because the action of development results in the production of soluble bromides, which are liberated in proportion to the amount of silver developed. Since bromide restrains development, local concentrations resulting from still development would render the whole process very uneven. The necessary agitation may be achieved in various ways, for example, by rocking or by brushing, or by the continuous motion of the material through the solution.

The Characteristic Curve (H. and D. Curve). The characteristic curve of a photographic emulsion consists of three parts: the under exposure region; the straight line portion where density is in proportion to log. Exposure, and the over exposure region where the curve again flattens out. If the straight line portion be extended, it will cut the log. Exposure axis at a point the exposure corresponding to which is called the inertia. This point was made by Hurter and Driffield the basis of their speed numbers. The tangent of the angle which the straight line makes with the log. E axis is known as gamma, and serves to measure the contrast, *i.e.*, the rate at which density grows as exposure increases. As development time is increased the value of gamma rises to a limiting value gamma infinity.

Strictly speaking, only on the straight line portion of the curve is proportional reproduction obtained, and only when the gamma is 1, that is, when the straight line makes an angle of 45° with the base is the scale of brightnesses exactly rendered. For gamma greater or less than 1 the scale is either extended or contracted, although correct proportional reproduction is still achieved. It must be remembered, however, that the production of the negative is only one stage in the process, and corrections can be applied during the making of the print.

The projection of the straight line portion of the characteristic curve on the log. E axis is the measure of the range of intensities (or subject brightnesses) which the material can record accurately. It is obvious that this, too, is dependent on the gamma to which the material is developed. The working range obtained by projecting the entire curve on the exposure axis is naturally much greater.

Two other important things which increase with time of development are (1) fog, and (2) graininess. Fog is the term applied to the density which is obtained on parts of the sensitive surface which have received no exposure. Graininess is more difficult to define. It is dependent upon the size of the developed grains, and upon the manner in which they are clumped together.

SPEED, CONTRAST, AND TIME OF DEVELOPMENT

We have discussed latent image formation and the production of a visible image by means of development. This has led us to a consideration of the characteristic curve. Now let us see what these things mean in practice.

When an exposed plate or film is put into a developer the highlights—or most heavily exposed parts of the negative—appear almost at once, next the middle tones appear, and finally the shadow details. If the film be taken out of the developer at this stage, a thin negative of soft gradation will be obtained. If, however, development be continued further, every tone will gain in density, but the highlights and middle tones will gain more rapidly than the shadows, which means that the negative will increase in contrast as well as density. If neither the emulsion nor the developer contained soluble bromide, no sensible increase in shadow detail would be noticeable on continuing development, but in practice all modern emulsions and most developers do contain bromide, and the result is that on increasing development, shadow detail not apparent on short development appears. Lengthening the time of development can, therefore, be said to increase both the speed and the contrast of the emulsion (where by speed we mean ability to record shadow detail), but there is a limit to which this can be carried. After a certain time in the developer, no further shadow detail will appear, and the emulsion has reached the maximum speed which it will reach in the particular developer used. The effective speed varies in different developers, and generally the more active the developer the greater the speed which the film will attain. For instance, with a weak developer such as paraphenylene diamine, most films reach an effective speed of less than half that possible with a powerful M.Q. developer.

The contrast behaves in much the same way, and after a time reaches its highest value (gamma infinity). Usually speed and contrast increase together, but this relationship varies with different emulsions. Fog and graininess increase also with increasing time of development. It will be seen that, if the highest effective speed of an emulsion must be used, development should be carried as far as possible without fog becoming too serious, but it must be understood that the resulting negative will be hard and tend to be grainy. In dealing with a seriously under-exposed negative, the only way to save it is to carry development to this point and to put up with the grain and the hard negative. This is, in fact, what is done by press photographers when circumstances force them to take pictures under conditions when they cannot avoid under-exposure.

With modern wide-aperture lenses and all the aids to exposure available, the photographer who concerns himself only with normal subjects should not obtain under-exposed results. It is nearly always

possible to give enough exposure to make it unnecessary to extract the last ounce of speed from the emulsion. This should obviously be avoided, because a hard and grainy result is the last thing the photographer wants. The harder emulsion which readily gives contrast and density, in practice works slower than the film of softer gradation, because the former film cannot be developed far enough to attain its greatest speed without obtaining a uselessly hard negative. This effect of contrast on speed is taken some account of in the exposure data issued by manufacturers for their various products. In practice, the speed of two emulsions which differ considerably in contrast cannot be compared at the same time of development. If a comparison in working speed is to be made, the plates or films should be developed to the same contrast. This means that the medium speed harder material should be given a shorter development than the fast, soft emulsion.

Speed Numbers and the Characteristic Curve. At the present time three systems of speed determination are in common use: H. & D., Scheiner, and Din, and not only do these methods differ very widely, but there need be no parallelism between the results obtained, because each system is concerned with a different aspect of the question. The response of the photographic emulsion is complex, and in any comparison between different emulsions, the results obtained depend on the conditions of exposure and of processing, as well as on the method of measurement and the particular conception of speed which is adopted. The earliest method of expressing the speed of a silver bromide-gelatin emulsion was described by Warnerke, who exposed plates behind a step wedge, each step of which had a density one-third greater than the one preceding, the steps being numbered with opaque figures. A candle or phosphorescent tablet was used as light source, and the highest number which could be distinguished on the developed plate was taken as indicating the speed of that plate. In this system, therefore, the speed of a plate or film is determined by its ability to give detail in the shadows. Twelve years later, Hurter and Driffield began the investigations which established the characteristic curve as the true guide to the behaviour of an emulsion. The characteristic curve is simply a diagram which shows the effect on the emulsion of every degree of exposure from under to over—for a particular development. To complete the story, several curves can be placed on the same piece of paper for different times of development.

The characteristic curve indicates the complete behaviour of the photographic material to light for any one development time and any particular developer. It supplies the H. & D. numbers, and by choosing particular densities on the foot of the curve, numbers corresponding roughly to those obtained by the Scheiner and Din systems can also be obtained.

Hurter and Driffield obtained the H. & D. speed number from the point at which the straight portion extended cuts the base line. The H. & D. speed number is thus derived from that part of the plate response curve in which correct reproduction is obtained.

The other two systems resemble more closely the Warnerke method, in that they derive their numbers from the under-exposure portion of the curve, although in neither method is the curve plotted. By the Scheiner system, emulsion speeds are determined by ascertaining the minimum exposure necessary to produce a visible image on the developed plate, which is examined visually whilst being held against white paper. The exposures are made by means of a sector wheel, and the source of light is the Hefner amyl-acetate lamp at a distance of 1 metre.

The third system in use is the Din, in which the light source is a 40-watt lamp, filtered so that it approximates closely to the colour quality of daylight, and the range of exposures is given through an optical wedge of thirty steps, the exposure time being constant and equal to one-twentieth of a second. Development is continued to give a maximum effect, and after processing, the plate is examined to determine the highest step wedge density which has produced a density of 0·1 above fog. If the fog is greater than 0·4 its value must be stated. Again, the similarity with the Warnerke system will be apparent.

It has also been suggested that a useful speed number could be derived from that point on the under-exposure region of the characteristic curve at which a certain minimum useful gradient (contrast) is achieved.

From the foregoing, it will be apparent that any one number can tell but a part of the story, and it will probably also be clear that numbers based on experimental exposure on average subjects, giving negatives just sufficiently well exposed to yield good prints, would probably form the most reliable guide of all. The important thing is that the numbers must, when used in conjunction with exposure tables or light measuring devices, indicate correct exposure times. If this linking or calibration is correctly done by experiment, it matters little how the original speed number was derived. In effect, it represents a working speed. It is important to realize, also, that for the purpose of achieving correct exposure, it is sufficiently accurate to divide materials into groups in which the average speed increases from group to group by a factor of 2. This is the basis of the Ilford group system in which the letters A, B, C, etc., are used to denote the working speed of any particular material. The slowest materials are in Group "A." As already mentioned, it is not possible to relate exactly speed numbers in any one system with those in another, but a rough correlation is given herewith which will be found sufficiently accurate for practical purposes.

ILFORD GROUP SYSTEM

Group G	5500 to 11000 H. & D.	Scheiner 34 to 36	Din 24/10 to 26/10
,, F	2500 to 5000 H. & D.	,, 31 to 33	,, 21/10 to 23/10
,, E	1200 to 2400 H. & D.	,, 28 to 30	,, 18/10 to 20/10
,, D	650 to 1000 H. & D.	,, 25 to 27	,, 15/10 to 17/10
,, C	300 to 600 H. & D.	,, 22 to 24	,, 12/10 to 14/10
,, B	160 to 280 H. & D.	,, 19 to 21	,, 9/10 to 11/10
,, A	50 to 150 H. & D.	,, 16 to 18	,, 6/10 to 8/10

TABLE OF WORKING CORRELATIONS BETWEEN ILFORD GROUP AND OTHER SYSTEMS

Ilford Group ...	A	B	C	D	E	F	G
Relative exposure ...	32	16	8	4	2	1	½
Smethurst High-light factor ...	1	2	4	8	16	32	64
H. & D. British ...	100	200	400	800	1600	3200	6400
including...	50/150	160/280	300/600	650/1000	1200/2400	2500/5000	5500/11000
Scheiner	17°	20°	23°	26°	29°	32°	35°
Weston (daylight) approx.	—	6–8	10–12	16–20	24–32	40–64	80–100
Burroughs-Wellcome (Col. I)	1/3–1/2	1/6–1/4	1/12–1/8	1/24–1/16	1/48–1/32	1/96–1/64	1/192–1/128
Compass Camera unit factor	+6	+4	+2	0	—2	—4	—6

The Nature of the Base. Photographic emulsions are generally coated upon one of three kinds of support—paper, glass, or film. Paper base is usually reserved for positive emulsions, although some negative emulsions are available on paper base. Negative emulsions are normally coated either upon glass or film.

Plates came first and even now they are used to a very large extent in certain branches of photography, because of many inherent advantages. The first thing which characterises the glass plate is its rigidity. During processing glass plates undergo no significant changes in dimensions, and this feature is particularly valuable in scientific work when accurate evaluation of image size is important. Similar conditions apply in Process and Three-colour work, when it is essential that positives made from separation negatives shall superimpose exactly. A further advantage is that no pains need be taken to ensure that the sensitive material lies flat in the camera—there is not the possibility of cockling which is always present with film.

An advantage which plates share with cut films and film packs, lies in the fact that each exposure can be treated as a separate unit, and can be given special attention during processing. A roll film may comprise a dozen different exposures on different subjects, and without going to a great deal of trouble all must be processed together. The case is worse with a miniature roll containing, say, 36 exposures. To be fair, however, it is necessary to add that developing to constant time and temperature is now the recommended practice. Individual special treatment is rarely beneficial, and so the ability to treat one exposure alone is mainly a matter of convenience.

Plates are, of course, at a disadvantage as regards the possibility of breakage, weight, space taken up for storage, and the fact that each must be loaded in the darkroom in a special darkslide.

In general, cut film and film packs can be regarded as constituting a compromise, possessing some of the advantages and some of the disadvantages of both plates and films.

The base used in the manufacture of films may be either cellulose nitrate or acetate, according to the particular product. The main disadvantage of the former is its inflammability. In some other respects it possesses advantages over the acetate base. Cellulose acetate is not, strictly speaking, non-inflammable—it is more correctly termed slow burning. The base is of different thicknesses according to the particular product—roll film is supplied on 3/1,000 in. base; X-ray film on 9/1,000 in. base; flat film generally on 8/1,000 in. base, and ciné film on 5/1,000 in. base. In all cases the base must be free from blemishes. It is normally clear and transparent, but may be coloured, and occasionally it may be rendered slightly diffusing.

All classes of emulsion, slow or fast, soft or contrasty, non-colour sensitive, orthochromatic or panchromatic, are available both on glass and on film. In the section which follows, some information is given concerning special features of commercially available sensitive materials.

Anti-halation Backings. These are designed to prevent the image spread produced by light which, after passing once through the emulsion, is reflected from the base back through the emulsion again. They act by absorbing the light after its first passage through the emulsion. With small images, and particularly with glass plates (in which case the reflecting surface is further from the emulsion than with film base), the image due to the reflected light may be completely separated from the true image. Another cause of image spread, which should not be confused with halation since it has nothing to do with the base, is irradiation due to scatter within the emulsion by the silver halide grains themselves.

The occurrence of both irradiation and halation may be simply explained as follows. Light falling on the surface of the emulsion is broken up into several parts. A portion of the light is reflected from the surface back towards the lens, and, so to speak, passes out of the picture. Part is absorbed by the silver halide grains without appreciable deviation from its original direction, and goes to form the image proper; part is scattered in all directions in the film and part passes through the film into the support. It is evident that the scattered light may be partly absorbed and partly passed on through the film; it is the absorbed part of the scattered light which produces "irradiation," the extent of the irradiation depending on how far away from the boundary of the image proper the scattered light is able to penetrate, and to what extent the light is scattered by the film. The light which passes through the emulsion enters the support and, according to the angle at which it meets the air-glass or air-celluloid surface, it may be reflected or may pass out of the support. The reflected light will

eventually reach the emulsion again and form an image at a little distance from the image proper. This secondary image is "halation"; it may take various forms according to the nature of the object, and is a complete circle (halo) for a small bright object.

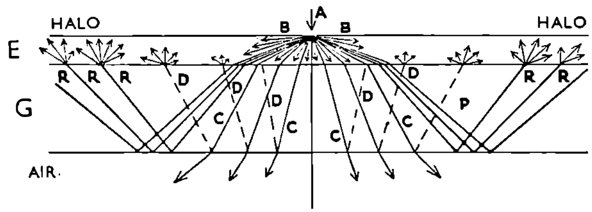


Fig. 49. Halation and Irradiation.

A careful study of the diagram (Fig. 49) will make both phenomena quite clear. Here BB shows light scattered in the emulsion at the point of incidence of a ray A. CC are rays which largely pass through the support, a small proportion being reflected (DD). Rays R R are totally reflected, giving rise to scatter of light in the emulsion coating.

Irradiation, as has been already mentioned, is a quality of the emulsion, and cannot be modified except by modifying the emulsion itself. Ilford Limited pay special attention to this property, and this defect is not one with which users of their plates or films will be troubled.

Halation, however, can be entirely prevented by coating the back of the emulsion support with a substance of suitable optical qualities, so that any light passing into the support will not be reflected by the back surface, but will pass through into the "backing" and be absorbed there. A red backing may be used for almost all plates or films other than panchromatic, but a special backing is necessary for these. One of the earliest backings used by Ilford Limited for application to plates consisted of a solution of caramel containing a mineral colour. A backing of this type was also a favourite one for photographers who preferred to back their own plates, and is, in fact, still at times recommended. There is, however, nothing for the individual worker to gain by backing his own plates, and, particularly for the fast varieties now common, any attempt at this would be distinctly ill-advised.

This early backing had various drawbacks from the manufacturer's, as well as from the user's, standpoint, and numerous other backings have been taken into use from time to time to overcome one or other of these defects. The earlier backings contained insoluble matter which formed a dirty sludge in the developer, unless trouble was taken to wash off the backing before development—quite a common practice at one time.

The present standard Ilford backings for plates disappear completely in the developer without leaving any stain or interfering in any way with the processing.

Similar backings have been adopted for films, the chief difference being that the dyes are added to the gelatin solution with which the back of the film is coated to prevent curl; also a red backing is used for film other than panchromatic.

With flat films a notching system enables the backing side to be distinguished from the emulsion-coated side. The notching (one V-shaped cut in the case of non-panchromatic and two cuts in the case of panchromatic materials) will be found at the right hand of the top (short) side when the emulsion is facing the operator.

Resolving Power. This may be defined as the ability of the plate to record fine detail. It depends upon grain size, graininess, coating weight, emulsion turbidity, development conditions, contrast, etc. Some approximate figures for resolving power are given herewith:

Gaslight lantern plate	3,150 lines/inch
Process films and plates	3,650 " "
Alpha lantern plate	3,800 " "
Thin film Half-tone plate	4,200 " "

For highest resolving power Ilford manufacture the H.R. plate which can resolve up to 5,500 lines per inch. These figures are for unfiltered half-watt light. Resolving power increases as the wave-length is reduced.

Sizes of Plates and Films. Plates are supplied in a great number of sizes as measured in inches or centimetres. Ilford plates are made in more than thirty British sizes (inches) ranging from $2\frac{5}{16} \times 1\frac{3}{4}$ in. to 24×20 in., and in nearly as many Continental sizes (centimetres). Sizes in most general use for amateur or professional and the names by which certain of them are known are as follows:—$3\frac{1}{2} \times 2\frac{1}{2}$ in., $4\frac{1}{4} \times 3\frac{1}{4}$ in. (quarter-plate), 5×4 in., $5\frac{1}{2} \times 3\frac{1}{2}$ in. (postcard), $6\frac{1}{2} \times 4\frac{3}{4}$ in. (half-plate), $8\frac{1}{2} \times 6\frac{1}{2}$ in. (whole plate), 10×8 in., 12×10 in., and 15×12 in. Of the Continental sizes, $4{\cdot}5 \times 10{\cdot}7$ cm. and 6×13 cm. are for stereoscopic photography.

The range of stock sizes of flat films runs from $3\frac{1}{2} \times 2\frac{1}{2}$ in. to 20×30 in., and from $4{\cdot}5 \times 10{\cdot}7$ cm. to 21×27 cm.

Both plates and flat films may, however, be obtained to order in larger sizes—plates up to 36×45 in. and films larger still.

Roll films are made in spools of 6, 8, 12, or 16 exposures for pictures ranging in size from $1\frac{1}{2} \times 2\frac{1}{4}$ in. to 7×5 in., the most popular size being $3\frac{1}{4} \times 2\frac{1}{4}$ in. (20), and next to that, $4\frac{1}{4} \times 2\frac{1}{2}$ in. (16).

On the four following pages is given a list of Ilford Plates and Flat Films and Selo Roll Films and Miniature Films, together with H. & D. and Scheiner speeds, and appropriate Ilford Group Numbers. Plates for scientific work and other specialized subjects are not included in the list. A brief description of each grade is also given.

Plates	Description	H. & D.	Scheiner	Ilford Speed Group
H.P.3	A plate of extreme speed specially valuable for the Press, and for all conditions where short exposures are essential or lighting is bad	6000	34	G
Hypersensitive Panchromatic	For high speed subjects and for night photography indoors and out. An excellent plate for Portraiture	3500	31	F
F.P.3	Exceptionally fine grain with high speed. For general photography, Press and commercial work	4500	32	F
Soft Gradation Panchromatic	One of the most popular plates for general work. Extensively used for portraiture	1200	28	E
Special Rapid Panchromatic	Fine grain. Fairly high contrast. General purpose plate. Widely used in scientific work; and in the photo-mechanical trade for block making, offset work and photogravure	700	25	D
Rapid Process Panchromatic	For copying coloured originals. A plate of high contrast. The standard plate for colour separation screen negatives for photo-lithography			
Thin Film Half-tone Panchromatic	The most contrasty of the panchromatic plates. For subjects wherever a panchromatic plate of maximum contrast is required. The best plate for direct screen negatives for colour blocks, also ideal for line negatives from coloured originals and in offset for the production of monochrome screen negatives			
Press Ortho Series 2	The best orthochromatic plate for Press work. Very fast. Produces sparkling negatives	3500	31	F
Selochrome	A fast plate for general purposes. Of average contrast. Fine grain and highly orthochromatic	1500	29	E
Golden Iso-Zenith	A fast portrait plate of soft contrast. Highly orthochromatic	1400	29	E
Iso-Zenith	For amateur and professional work, gives negatives of excellent gradation. Very fine grain	700	25	D
Chromatic	Highly yellow and orange-yellow sensitive. Valuable for copying old yellow manuscripts. A suitable plate for photogravure negatives	135	18	A
Special Rapid	For subjects of normal tone-range. Of moderate contrast and extremely fine grain	270	21	B
Ordinary	For copying and enlarging and for all subjects where colour sensitivity is not important. Very suitable for the negatives or the positives when making blocks by the indirect method, and for the first negative in indirect monochrome photo-lithography. Also a most suitable plate for the continuous tone positives. Widely employed in photogravure work			

Plates	Description	H. & D.	Scheiner	Ilford Speed Group
Process	Of high contrast. Extremely fine grain. For process work, copying black-and-white originals, etc. Very suitable for the making of screen negatives			
Thin Film Half-tone	Extremely high contrast. For copying line drawings and other black-and-white subjects. Specially suitable for screen negatives for monochrome blocks. Also for line negatives			
Special Lantern	For contact, enlarging and reduction work. The fastest of the lantern plates Available in three contrasts: Soft, Normal, Contrasty			
Warm Black Lantern	For contact and reduction work. Gives pleasing warm black tones. Sepia and red are obtained by the use of a pyro developer			
Gaslight Lantern	For contact work. Of high contrast. Specially suitable for weak negatives			

Flat Films	Description	H. & D.	Scheiner	Ilford Speed Group
Hypersensitive Panchromatic H.P.3	An extremely fast film for general purposes, especially valuable for night photography indoors and out. An excellent film for portraiture	5000	32	F
Portrait Panchromatic	Specially designed for the portrait photographer working with half-watt lighting. Blues and reds are well reproduced. Gives negatives of soft gradation	2000	30	E
Process Panchromatic	For copying coloured originals where maximum contrast is required. Employed for three or four colour blocks. Very useful for monochrome screen negatives from coloured originals. Widely used In conjunction with Ilford line film for preparing monochrome screen negatives for offset			
Selochrome	A fast film for general purposes. Of average contrast, fine grain and highly orthochromatic	1500	29	E
Hyperchromatic	A fast orthochromatic portrait film of soft gradation	1500	29	E
Portralt Ortho Fast	A medium speed orthochromatic portrait film of soft gradation	700	25	D
Commercial Ortho	A convenient film for copying yellow or discoloured originals and for all copying work where full colour sensitivity is not required			

Flat Films	Description	H. & D.	Scheiner	Ilford Speed Group
Fine Grain Ordinary	Similar in characteristics to Ilford Ordinary plate. A useful film for all copying work other than coloured originals. The most widely used film for photogravure positives. Also used considerably for photogravure negatives			
Process Film	Similar in characteristics to Ilford Process plate. Of high contrast. Extremely fine grain. For process work, copying black-and-white originals, etc. Very suitable for the making of screen negatives			
Line Film	A film of extremely high contrast and very fine grain. Specially suitable for screen or line negatives for monochrome blocks, and for screen or line negatives for printing direct on to the offset plate. Widely used for the final negatives in indirect colour offset. An excellent film for line or text negatives in photogravure			
Diapositive	For contact, enlarging, and reduction work			

Roll Films	Description	H. & D.	Scheiner	Ilford Speed Group
Selo H.P.3	For high speed subjects and for night photography indoors and out. Fully colour-sensitive	5000	32	F
Selo F.P. (Fine Grain Panchromatic)	For general photography. Very fine grain. Specially designed for considerableenlargement. Fully colour-sensitive	1000	27	D
Selochrome	A fast colour-sensitive film for snapshots and landscapes. Highly orthochromatic	1500	29	E
Selo Ortho	For snapshot work. Excellent latitude	750	26	D

35 mm. Miniature Camera Films	Description	H. & D.	Scheiner	Ilford Speed Group
Selo H.P.3	For high speed subjects and for night photography indoors and out. Fully colour-sensitive	5000	32	F
Selo F.P.2	For general photography. Very fine grain. Specially designed for considerable enlargement. Fully colour-sensitive	1000	27	D
Micro-neg	For the micro-copying and duplication of business records. Extremely high resolving power with high contrast			
Diapositive	Suitable where the degree of reduction is not excessive and the original is black and white only. Valuable for making positives from existing negatives			

Some of the more popular brands of Ilford plates listed in order of decreasing contrast:—

Hard—Thin Film Half-tone
Thin Film Half-tone Panchromatic
Ortho Process
Process
Rapid Process Panchromatic
Chromatic
Ordinary
Infra-red
Special Rapid Panchromatic
Special Rapid
F.P.3
Iso Zenith
Zenith 700
Selochrome
Press Ortho Series 2
H.P.3
Soft Gradation Panchromatic
Golden Iso Zenith
Hypersensitive Panchromatic

Ilford Flat Films arranged in order of decreasing contrast:—

Contact
Line
Ortho Line
Process
Process Panchromatic
Diapositive
Fine Grain Ordinary
Commercial Ortho
Selochrome
H.P.3
Portrait Panchromatic
Hyperchromatic
Portrait Ortho Fast

RECENT INTRODUCTIONS

Two new plates recently introduced by Ilford Limited deserve special notice. The first, Ilford H.P.3, is the fastest panchromatic plate available. It has a speed rating of 6000 H. & D., 34°, Group G, and is twice as fast in half-watt light as the older H.P.2 plate. The increased speed has been achieved without sacrificing any other quality and there is no increase in grain size or graininess. For subjects in rapid motion, indoor work by artificial light, and for all subjects which have to be taken under poor lighting conditions, this plate should prove very nearly ideal.

Filter Factors:	Red	Green	Blue	Gamma
Daylight	4	6	7	3½
Half-watt	2¼	7	20	3

Development:—Formula ID-2 is recommended and the times of development are as follows:—

	55°F. (13°C.)	65°F. (18°C.)	75°F. (24°C.)
Dish	7½ min.	5 min.	3½ min.
Tank	15 ,,	10 ,,	7 ,,

For Fine Grain Development the Ilford M.Q. Borax formula ID-11 is recommended, with which a time of 15 mins. at 65°F. is advised.

Ilford F.P.3—the second plate mentioned above—represents the fastest plate available in the fine grain class. It is rated at 4500 H. & D., 32°, Group F, and is approximately twice the speed of the older F.P.2 plate. This plate will give negatives of the same general character as those obtained with the H.P.3 plate, but they will have finer grain to balance off against the reduction in working speed. The choice as to which material should be used will depend entirely on which of these considerations is the more important.

Filter Factors:	Red	Green	Blue	Gamma
Daylight	4	6	7	3½
Half-watt	2¼	7	20	3

Development: Formula ID-2 is recommended and the times of development are as follows:—

	55°F. (13°C.)	65°F. (18°C.)	75°F. (24°C.)
Dish ..	4½ min.	3 min.	2 min.
Tank ..	9 ,,	6 ,,	4 ,,

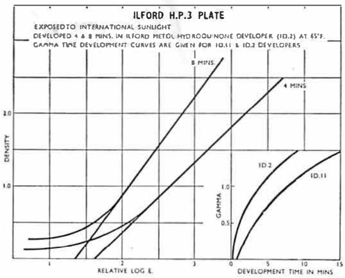
Alternatively, the Ilford M.Q. Borax formula ID-11 may be used and with this developer a time of 9 mins. at 65°F. is advised.

CHARACTERISTIC CURVES OF SOME ILFORD PLATES

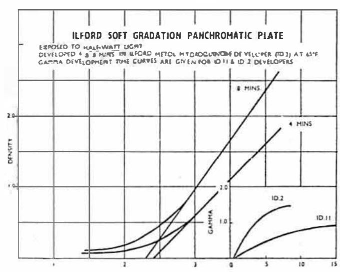
Developed in Ilford Metol Hydroquinone Developer ID-2 at dish strength, with Gamma Time Development Curves for both ID-2 and ID-11 Developers.

PANCHROMATIC PLATES

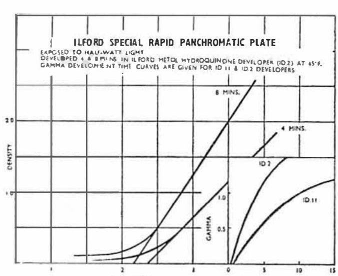
H.P.3 PLATE



SOFT GRADATION PANCHROMATIC PLATE

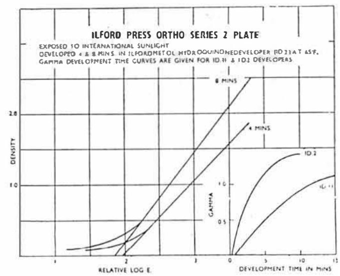


SPECIAL RAPID PANCHROMATIC PLATE

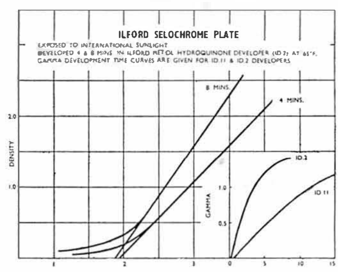


ORTHOCHROMATIC PLATES

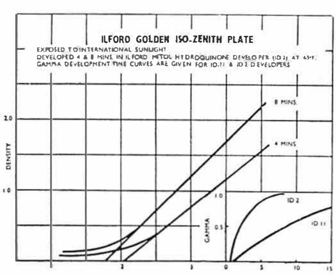
PRESS ORTHO SERIES 2 PLATE



SELOCHROME PLATE



GOLDEN ISO-ZENITH PLATE

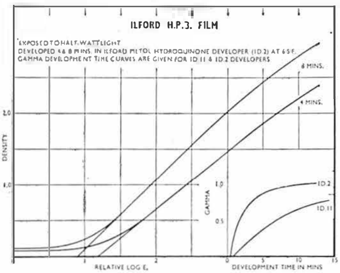


CHARACTERISTIC CURVES OF SOME ILFORD AND SELO FILMS

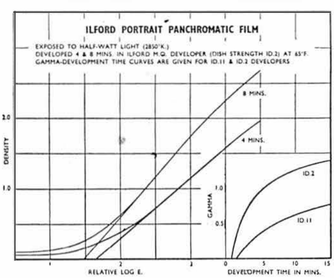
Developed in Ilford Metol Hydroquinone Developer ID-2 at dish strength, with Gamma Time Development Curves for both ID-2 and ID-11 Developers.

ILFORD FLAT FILMS

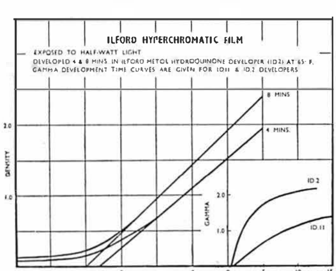
H.P.3 FILM



PORTRAIT PANCHROMATIC FILM

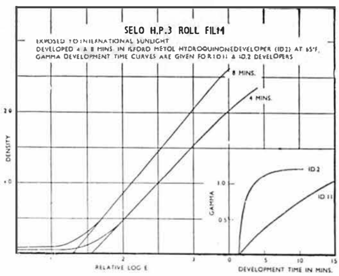


HYPERCHROMATIC FILM

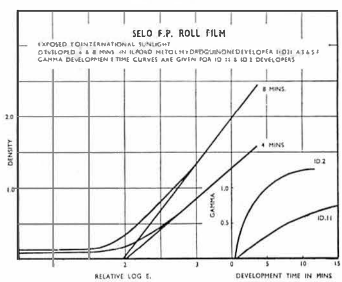


SELO ROLL FILMS

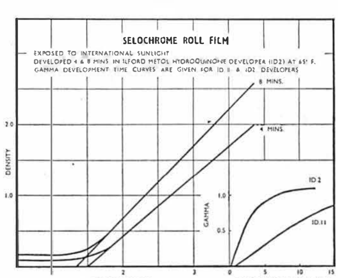
SELO H.P.3



SELO F.P.



SELOCHROME



CHAPTER IV

THE TRANSLATION OF COLOUR INTO BLACK AND WHITE

In Chapter I a brief description of the nature of light was followed by a discussion of the mechanism of optical-image formation. In Chapter II light was considered in relation to the formation of the latent, developable, photographic image. We shall now proceed to a discussion of light in terms of colour quality, with particular reference to the manner in which the coloration of objects is dependent on the spectral composition of the illuminant. From this we shall pass on to consider colour vision and the response to different colours of the principal types of photographic emulsions. We shall then be in a position to see how, by means of light filters, the plate or film may be made to respond to colour in any desired manner.

We have seen that white light can be separated by means of a prism into light of the constituent colours—violet, blue, green, yellow, orange, red. Beyond the extreme colours of the visible spectrum there lie two regions of radiation—the infra-red and the ultra-violet—both invisible to the human eye, but of great photographic importance.

The pure colours of the spectrum are rarely to be found in the objects which we see around us; instead, we see many colours not to be found in the spectrum. This does not mean that light of a different nature is emitted by these objects, but simply arises from their power of selective absorption—in general, any common object assumes a colour which is a mixture of the spectral colours present in the illuminant and not absorbed by the object. Thus, if the illuminant contains no red at all, then no matter how red the object may appear in other circumstances, it cannot appear red in that particular light. To take a slightly more complicated example, let us consider an object which absorbs all green and yellow light falling upon it. When illuminated with white light it reflects back violet and blue from one end of the spectrum, with orange and red from the other. The eye sees a shade of magenta due to the mixture of the colours reflected and that this colour is derived entirely from the illuminant can be readily demonstrated if we remove the source of white light or "continuous" radiation and use instead a "discontinuous" source emitting radiation of certain spectral colours only. Lights of this type are now familiar to us in the modern high-power street-lighting installations which make use of mercury ("Osira")

or sodium discharge tubes. The "Osira" lamp emits radiation mainly of three colours, violet, green, and yellow, and will thus, by absorption of its green and yellow components, reveal the object as being violet in colour. With a sodium lamp, on the other hand, which emits yellow radiation only, no light will be reflected back at all, so that the object will merely appear to be grey or black.

The photographic emulsion reproduces colours in monochrome and it is considered to do so faithfully when the relative brightness of the greys produced are in agreement with those of the colours as seen by the eye. Where the subject is viewed in the same light by which the photograph was made then the faithfulness with which the translation is effected depends on the photographic emulsion alone. If, however, as is often the case, the subject is normally viewed in a light other than that by which the photograph is taken, then the difference between the colour qualities of the two sources must also be taken into account. It must also be recognized that faithful reproduction is not always desirable; it is sometimes necessary, as will be seen later, to produce deliberate falsification.

From the physical standpoint, radiation is a form of energy, and the colour quality of a light source may be defined by the manner in which its emission of energy is distributed throughout the spectrum. For most sources of continuous radiation, this distribution may be conveniently specified in terms of the temperature on the Absolute or "Kelvin" scale to which it would be necessary to raise an ideal non-selective radiating substance, known as a "black-body" radiator, to obtain the same distribution of energy. Luminous sources of low colour temperature are characterized by an energy distribution relatively rich in red radiation, but as colour temperature rises, so the emission of energy becomes more evenly distributed, and the whiter becomes the light. It is obvious, of course, that colour temperature can only be ascribed to sources of continuous radiation and that even with these there are certain exceptions. It is sometimes convenient to define a colour quality as being equal to that provided by a metal filament lamp operating at a certain colour temperature and screened by a specified filter.

LIGHT SOURCES IN COMMON USE IN PHOTOGRAPHY

Practically all sources of light in common use for photographic work, with the exception of the mercury discharge tube, can be described as giving white light. This term is used in rather a loose way to describe light which is not very noticeably deficient in any particular colour, but it does not imply any very definite colour quality

A great deal of photographic work is done out of doors in ordinary daylight, the quality of which can vary very considerably according to whether the sun is shining in a clear sky, or is obscured by cloud, and according also to its height in the sky. Absorption

and scattering are greatest when the sun is low because of the greater atmospheric depth through which the light must come—the reddening of the light towards sunset is a matter of common observation.

These fluctuations prohibit the use of ordinary daylight for the testing of photographic materials in the sensitometric laboratory. Here it is essential to use light sources of fixed colour quality, and for standard daylight it has been agreed to take a certain average quality (see Fig. 49a) representing Mean Noon Sunlight at Washington. To illustrate the wide variety of quality exhibited by illuminants commonly regarded as sources of white light, spectral-energy distribution curves for the light from a clear blue sky and

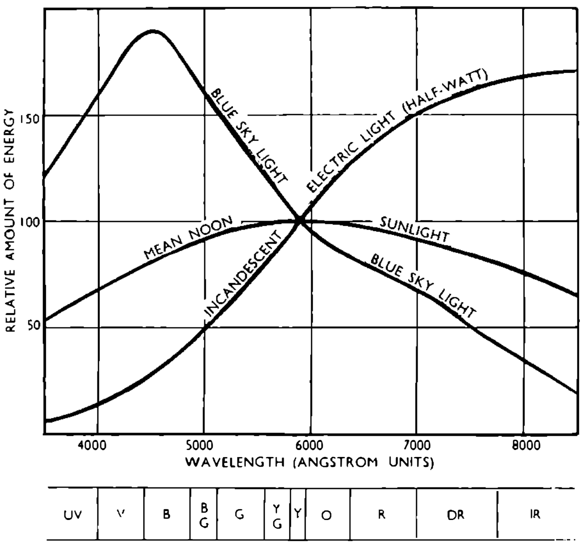


Fig. 49a

from an ordinary metal filament electric lamp have also been included in Fig. 49a. It will be noticed that the former is, as would be expected, particularly rich in blue radiation, while the latter has relatively a very high red content.

The gas-filled metal filament lamp is the most commonly used of artificial light sources. Normally-run lamps have a life of about 1,000 hours and a colour temperature of about 2,850°K. The blue content is relatively low, but by increasing the applied voltage, the colour temperature and thus the blue content can be considerably increased. It is unsafe to over-run ordinary lamps in this way to any considerable extent—an arc may form between the filament supports and the bulb fly to pieces—but special photoflood lamps

incorporating internal fuses, are available, which are perfectly safe. These lamps run at a colour temperature of about 3,600°K. As an example of the use of a colour filter for the modification of colour temperature we may mention the specification for the laboratory production of Mean Noon Sunlight. This involves the use of an incandescent electric lamp running at a voltage such that the colour temperature is 2,360°K. and screened with a Davis-Gibson filter to raise the colour temperature to the required value of 5,200°K.

Carbon arc lamps find employment in process work, where their high blue-violet content is an advantage, and also in cinematography, both for projection work and for illumination of the studio sets, where sources of very high intensity are required. Plain carbon arcs can be operated to give a colour temperature of 3,815°K., while 5,000°K. is possible with the use of special high-intensity carbons.

For special laboratory work the Pointolite lamp (glowing tungsten ball heated by an arc) is very convenient, and provides a very intense light source of small dimensions. For this reason it has also found favour in photomicrography. The colour temperature of the light is approximately 2,900°K.

Mercury vapour discharge lamps are used to a considerable extent to provide large extended sources in certain types of enlargers. Their use has also been suggested for studio lighting, but in general the discontinuous spectrum of the light emitted has been a serious disadvantage. Attempts have been made with some success, however, to supply the missing radiations by using the tubes in conjunction with metal filament lamps, and also by introducing suitable fluorescent materials into the tubes. In modern high-pressure mercury lamps the spectral lines are broadened somewhat and are superimposed upon a continuous spectrum of lower intensity, so that the deficiency is not so great. The advantages of discharge lamps are economy in current consumption and relative absence of heat emission.

Flash powder of various kinds was used for many years by press photographers and others who were required to make pictures in circumstances where the normal lighting was insufficient for their purpose. Such powders were effective, but the smoke produced was a great disadvantage. Electrically-operated flashbulbs, containing aluminium foil or wire in an atmosphere of oxygen at low pressure, have now largely displaced powders for this purpose and these, of course, are perfectly clean in action. They can be obtained to operate from dry batteries or on the normal mains supply, according to requirements. The colour temperature of the flash is between 3,400°K. and 3,600°K., its maximum intensity about 360,000 candles, and its duration from 1/20th to 1/75th second. The output curve obtained by plotting intensity against time rises quickly to a sharp peak and falls away again rapidly to zero; wire-filled lamps are

stated, however, to have a flatter curve than those containing foil.

It was formerly the practice to fire off a flash with the camera shutter left open. Recently, however, a number of devices have been marketed which enable shutter and flash to be synchronized. In this way it is possible to limit the exposure to the very peak of the flash and thus to take pictures of subjects in very rapid motion.

The difference in colour quality between daylight and artificial light is sufficiently great to affect the visual appearance and brightness relationships of coloured objects. Photographic reproduction will also show differences unless control of the type which is about to be described is exercised. With black-and-white subjects, however, the differences in colour quality are less serious and except

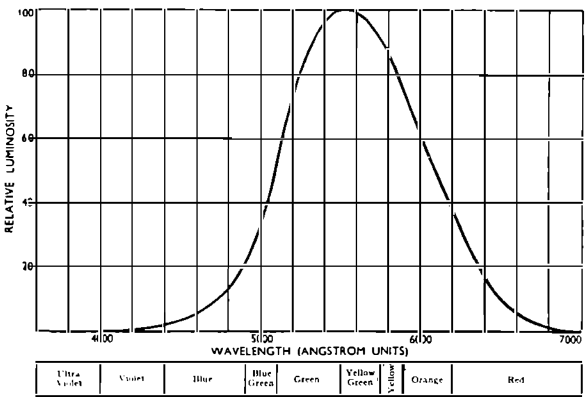


Fig. 50.

where mercury discharge tubes are being used can usually be neglected. On the other hand, the preparation of reproductions in colour calls for the most accurate control of the quality of the lighting if good results are to be obtained.

THE RESPONSE OF THE HUMAN EYE TO COLOUR

It is a commonly recognized fact that the normal human eye does not see all colours equally brightly. Most blues, for example, when compared with medium shades of orange or green are said to be dark colours, while yellows, including even the deepest shades, are regarded as being amongst the lightest of colours. If we return for a moment to our consideration of the spectrum of white light, it is possible to illustrate this state of affairs diagrammatically by means of the "visibility" curve (Fig. 50).

This shows us exactly how the human eye would respond to the series of pure spectral colours obtained by splitting up a beam of pure white light, to which sunlight approximates closely. It is interesting to notice how many times the luminosity of the brightest

colour, yellow-green, exceeds that of colours nearer the ends of the spectrum. So pronounced, indeed, is this predominance, that it holds good for the less evenly balanced forms of continuous radiation already discussed, such as light from a blue sky, or from a metal filament lamp. Thus, although with these illuminants the relative luminosities of red and blue, for example, may change with respect to one another, the characteristic form of the visibility curve remains unaltered.

Having established this relationship between the brightness of colours, the way has been cleared for a discussion of how coloured objects can best be represented in a black-and-white photograph. So far as a response to light and shade is concerned, and this, of course, has a very large part to play in the photographic rendering of the form and structure of a subject, it is clear that any type of light-sensitive material will answer the purpose. If, however, our photograph is to reproduce at the same time the colours of the subject in a scale of tones corresponding with their true luminosity values, then it is essential that the film or plate employed shall have a spectral response corresponding exactly with that of the human eye.

COLOUR SENSITIVITY OF THE PRINCIPAL NEGATIVE MATERIALS

Photographic plates and films which are available at the present day are commonly classified in three groups, known as ordinary, orthochromatic, and panchromatic. In the case of the ordinary variety, the response is confined to the blue and violet end of the visible spectrum, but extends at the same time far into the invisible ultra-violet region. This class of material, which is frequently referred to as "non-colour sensitive" or "colour blind," was in fact the only type available until the discovery of sensitizing dyes made it possible to extend the region of sensitivity further into the visible spectrum. (Fig. 51.)

Orthochromatic materials are sensitive to green, and some modern highly orthochromatic types to yellow also, while panchromatic materials, in addition to these colours, respond also to red, thus covering the whole visible spectrum. It should be noted that colour sensitization is in every case additional; thus, both the orthochromatic and panchromatic varieties include the initial blue, violet, and ultra-violet sensitivity of the ordinary emulsion. (Figs. 52 and 53.)

THE PHOTOGRAPHY OF COLOURED OBJECTS

We have now discussed all the factors which were mentioned in the introduction as having a part to play in the making of satisfactory monochrome photographs of coloured subjects, and are in a position to consider the question of colour filters themselves.

It is at once clear that only one of the three groups of light-sensitive materials discussed on p. 86, namely, the panchromatic, can be successfully employed for the photography of multi-coloured objects, since it is the only one which responds to the whole of the visible spectrum. Unfortunately, no type of panchromatic emulsion

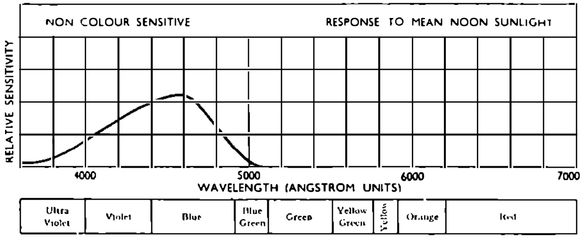


Fig. 51

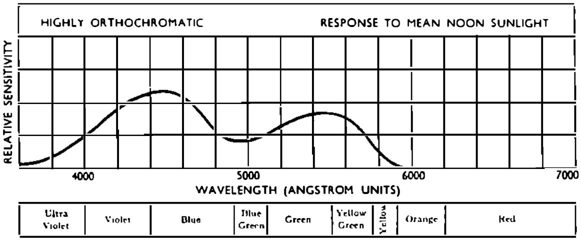


Fig. 52

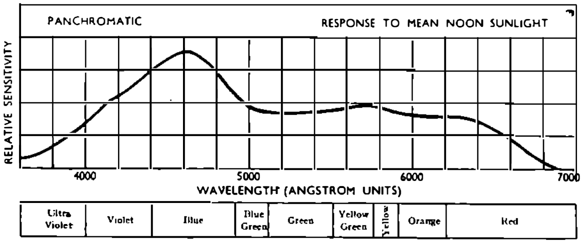


Fig. 53

yet made responds to the different colours of visible radiation in the same manner as the human eye, a fact which can be made more readily apparent if we take the panchromatic sensitivity curve from Fig. 53 and replot it in one diagram with the visibility curve already illustrated in Fig. 50. (See Fig. 54.)

The response to colour of the photographic material, which may be taken as typical of panchromatic emulsions as a whole, can now be seen to be quite different from that of the human eye. The

characteristic peak of visibility in the yellow-green coincides with a region of comparatively low photographic response, while at the same time the relative sensitivity of the panchromatic material greatly exceeds that of the human eye for violet, blue, and red.

Because of these very different characteristics it becomes necessary, therefore, to modify the photographic response. This can be done by means of colour filters, which are simply sheets of glass or gelatin having the power to absorb certain colours either partially or completely, while transmitting others freely. By the correct choice of a filter it becomes possible to reduce the intensity of colours reaching the plate to which the response is too strong. At

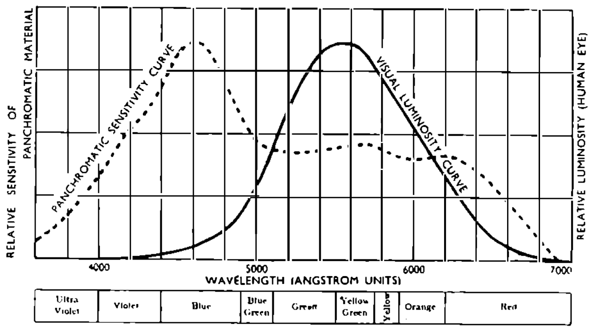


Fig. 54.

the same time, light of other colours to which the response is comparatively weak, has more time in which to act, because since the filter does its work by the removal of some of the active light a longer exposure is now required. The actual ratio of the filtered exposure to the corresponding unfiltered exposure is known as the "exposure factor" or "filter factor," and, for any given filter, depends for its numerical value upon the colour sensitivity of the photographic material used, and upon the "quality" of the light illuminating the object to be photographed.

CORRECTION FILTERS

Filters used in the manner just described, that is, for the purpose of making the photographic material see objects as the eye sees them, are commonly called "correction filters," a group which includes a long series of yellow and yellow-green filters. Since it is the violet and blue sensitivity of the film or plate which is so predominant, much can be done by the partial absorption of these colours only. Filters which do this are yellow in colour, and are available in a wide range of depths. For perfect correction, however, red must be partially absorbed as well, so that fully-correcting filters are yellowish-green in colour. A very important filter in this class is the Ilford

Gamma, which has been designed for use with Ilford Panchromatic materials, and by applying the right degree of absorption for every colour of the spectrum actually gives true correction to eye sensitivity.

At first sight it would appear that the photographer armed with a camera loaded with an Ilford Panchromatic Plate or Film, and fitted with a Gamma filter, is in a position to photograph successfully any coloured object, but this is actually far from being the case. While this combination is undoubtedly the correct one for dealing with such work as the copying of coloured pictures, the photography of stained-glass windows and in general all brightly coloured objects, there are many circumstances where such perfect correction is quite unnecessary, and some indeed where it is actually undesirable. In some cases also the comparatively high-exposure factor of the Gamma filter is inconvenient if a very short exposure has to be given, and quite frequently a satisfactory amount of correction can be obtained by using a much paler green filter with a smaller exposure factor, such as the Ilford Beta.

LANDSCAPE PHOTOGRAPHY

Landscape work is a very important example of the class of photography where the full correction of the Gamma filter is usually unnecessary, and is in addition quite frequently incapable of giving the most pleasing results with the scene in question.

Mention has already been made of the fact that the general form and structure of subjects are largely revealed by their relative brightnesses as distinct from colour values. That is to say, the different parts of the subject exhibit varying degrees of light and shade depending upon their relative powers of reflection and upon the angle of the lighting. If now we consider again for a moment the stained-glass window mentioned in connection with the Gamma filter, it is readily apparent that we have here a case where light and shade play only a very subordinate part, and colour is the important factor. This is an extreme case, but practically all landscapes are examples of the opposite case where colour plays the less important part. It follows, therefore, that reasonably satisfactory photographs can here be taken without panchromatic emulsions, and quite frequently even with "ordinary" materials.

Most landscape colours are greens and browns of a comparatively dull hue, and consist rather of white light tinged with colour than of very bright or definite colours, a state of affairs which becomes more marked with increasing distance. The only really bright colour normally met with is that of the blue sky on a clear day, and this presents an important problem since whatever class of photographic material we use, the response to blue is so great that the sky is generally recorded as a uniform white area devoid of cloud detail.

The yellow correction filter already mentioned can, by applying varying degrees of blue absorption, rectify this situation, although little can be done with ordinary emulsions since even a filter of medium strength absorbs the greater part of the light to which they are sensitive. With orthochromatic materials, a good sky rendering is obtainable with one of the palest correction filters, Alpha, while Iso, a rather deeper yellow, gives a little more contrast. If still darker skies are required, then a deep yellow filter, Delta, which absorbs violet completely and blue very heavily, can be employed, but the exposure factor (4) is rather high and deeper filters are out of the question.

Working with panchromatic materials, the filters already mentioned can again be utilized with very similar results, and still more dramatic effects can be obtained by using filters which cut off progressively more of the blue end of the spectrum, such as Micro 4 (very deep yellow), Micro 5 (orange), or even Tricolour Red. Provided that all the landscape colours are unsaturated, little else but the sky will be greatly affected, but orange and red filters should be avoided if there is foliage in the foreground. This is especially important in the spring, when the fresh greens may be sufficiently bright, even in the middle distance, to be rendered too darkly by these green absorbing filters. In these circumstances the best filter to use is a yellow of medium strength such as Iso, or a pale yellow-green such as Beta.

HAZE PENETRATION

Another very important application of the series of yellow, orange and red filters just discussed is their use as haze penetrators. Distant objects, viewed through a mist, suffer both from loss of definition and of contrast because the light reaching the observer has been scattered by suspended particles of dust and water in the atmosphere. The amount of direct light reaching the eye, and by which the image is formed, is thus reduced, and further, its effect is swamped because of the general illumination of the retina by the scattered light. An important aspect of this scattering is that it is not equally strong for all colours. The effect is indeed at a maximum for ultra-violet radiation, and decreases steadily as we pass through the visible spectrum from blue to red, reaching a minimum in the infra-red. Thus the direct light tends to have a relatively higher red content than the original radiation, while the scattered light has a correspondingly higher blue content. This fact is readily apparent when a row of street lamps is viewed on a misty night; the more distant the lamp the redder does its light appear to be.

The photographic plate is far more handicapped than the human eye by mist, simply because it happens to be so greatly sensitive to blue, violet, and ultra-violet light, the very group of radiations for which the scattering effect is most pronounced. Fortunately, colour

filters enable us to prevent the strongly scattered radiation from recording. All that is necessary is to select a filter which absorbs heavily at the blue end of the spectrum while transmitting freely at the red end. It should be noted that all the Ilford Correction Filters eliminate ultra-violet completely, and an astonishing improvement can be obtained in a hazy atmosphere even with the pale yellow Alpha filter. For heavier mist the best results can only be obtained, however, by working more nearly to the red end of the spectrum, and with this ideal in view the greatest penetration will be given by a panchromatic material used with an orange or red filter.

At the same time it is not always desirable to eliminate haze altogether. In pictorial work, for example, much of the artistic appeal of a landscape may thereby be lost, in addition to the sense of perspective which depends very largely upon the increasing mistiness of the receding planes; it is important therefore in this class of work to avoid too heavy a filter, and in most cases a medium yellow will be found sufficiently strong. Mountain photography at high altitudes is also a case which requires rather careful treatment. A cloudless sky, especially in winter, appears a very deep blue indeed, and any filter heavier than the palest yellow will make it appear too black, particularly if contrasted with snow. The ultra-violet content of the mountain light is, however, much higher than at sea level, so that haze will be very troublesome if no filter is used at all; a very useful aid in these circumstances is a colourless ultra-violet absorbing filter such as the Ilford "Q." This transmits visible light freely, and is thus capable of improving penetration without exaggerating the colour values of the scene.

CONTRAST FILTERS

In our discussion of the choice of filters for landscape work, mention has been made of the increasingly dark rendering of the blue sky which can be obtained by going beyond the yellow correction filters proper, and using very deep yellow, orange, or even red filters. The results obtained with these latter are not, of course, correct according to a visual estimate of the colour luminosities involved, but are intentionally exaggerated for the sake of pictorial effect. Filters used in this manner may more properly be referred to as "Contrast" filters, and a further consideration of the "Visibility" curve will readily show that cases can frequently arise where "Contrast" rather than "Correction" filters are required. Let us consider a simple example by way of illustration.

The points marked "G" and "O" on the curve Fig. 55 represent the luminosities of two selected colours in the spectrum, a certain shade of green, and a certain shade of orange, and it will be noticed that the choice of these particular colours has been so made that their visual luminosities are equal. Now while the diagram refers to the pure colours of the spectrum, it is not at all a difficult matter

for the sake of argument to find some natural object whose coloration includes a green and an orange of equal brightness. This is quite clearly a case where the Gamma filter will fail hopelessly, for while the eye finds the colour contrast of the two shades very marked, the panchromatic plate, under the correcting influence of the Gamma filter, will proceed to render both colours, because of their equal luminosity, in precisely the same shade of grey. If the two colours are to be distinguished photographically, a false rendering must therefore be employed; in fact, two renderings are open to the photographer, for he can either make the green light and the orange

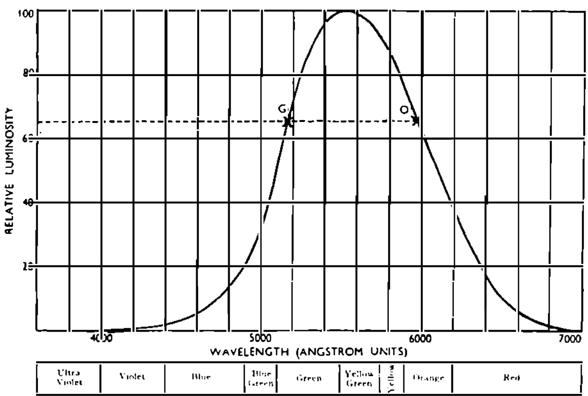


Fig. 55.

dark, or the green dark and the orange light, at will. The rule for arriving at these results is very simple, for all that is required is to choose a filter which is itself as nearly as possible the same colour as the hue which is to be given the lighter rendering of the two; thus, for the first rendering, a green filter, such as Tricolour Green, is required, and for the second, an orange filter, such as Micro 5. It is important to notice that filters employed for contrast work should transmit their own colour as freely as possible while absorbing all other parts of the spectrum very heavily.

DETAIL FILTERS

Another class of problem which is frequently encountered is that of photographing objects which are of a practically uniform colour. There is often in such cases great difficulty in obtaining a successful rendering of detail, which depends for its visibility to a great extent upon the varying amounts of light of the particular colour in question reflected from the different parts of the surface. A second simple rule, however, makes a successful result easy of attainment, for the choice is once again with a contrast filter, the colour of which should

be as near as possible to the hue of the object to be photographed. Perhaps the best known example of the use of detail filters is in the photography of polished woodwork, where the striking success of the orange Micro 5 filter in bringing out the beauty of the grain of dark oak and mahogany has earned for it the nickname of "Furniture Red."

A CONCISE GUIDE TO THE SELECTION OF FILTERS FOR CORRECTION, CONTRAST, AND DETAIL

In the following summary of the uses of Ilford Filters, it has been assumed throughout that panchromatic plates or films are being used. In cases marked thus * however, orthochromatic material could also be employed.

LANDSCAPE WORK—SKY CORRECTION

*PALE YELLOW No. 103 (CHROMATIC 1)—specially recommended for improved sky rendering with orthochromatic materials where only a small exposure increase is permissible.

*YELLOW No. 104 (ALPHA)—a useful general-purpose filter for deepening the tone of the sky. Gives good contrast when there are brilliant white clouds in a clear blue sky.

*YELLOW No. 105 (ISO)—a deeper filter which may be used with advantage in place of Alpha if the sky is somewhat hazy—especially on sunny days in winter. Also very suitable for springtime scenes with fresh foliage in the foreground.

*DEEP YELLOW No. 109 (DELTA)—for use when blue sky is very pale, or for obtaining strong cloud and sky contrast on clear days.

DEEP YELLOW No. 110 (MINUS BLUE).

ORANGE No. 202 (MICRO 5).

RED No. 204 (TRICOLOUR RED).

These three filters are only to be used in cases where extreme contrast is required. In clear, bright weather No. 204 renders the sky almost black. As all these filters over-correct green, they must be avoided in cases where there is green foliage in the foreground (compare Iso filter for spring foliage).

GREEN No. 401 (BETA)—gives approximately the same sky correction as Iso, but is useful for subjects containing reds and browns in the foreground, and as an alternative to Iso for spring foliage.

LANDSCAPE WORK—HAZE PENETRATION

All the yellow and red correction filters above mentioned may be used as haze penetrators.

*YELLOW No. 102 (AVIOL)—this filter is useful for aerial survey work where increased penetration is required with the minimum possible increase of exposure.

*Yellow No. 104 (Alpha) may be also used for the same purpose.

RED No. 204 (TRICOLOUR RED)—gives the maximum penetration obtainable with panchromatic materials. If the permissible exposure precludes the use of so heavy a filter, use should be made of No. 202 (Micro 5), or even of the heavier yellow filters No. 109 (Delta) or No. 110 (Minus Blue) if very short exposures are necessary.

*No. 805 (Q)—this colourless ultra-violet absorbing filter may be used with advantage for high-altitude mountain photography, especially on clear sunny days in winter, when yellow filters tend to darken the sky too much.

MONOCHROME RENDERING OF BRIGHTLY COLOURED SUBJECTS

GREEN No. 402 (GAMMA)—for use with subjects where colour values play a stronger part than shadow detail; gives a correct monochrome rendering of the colour luminosities. Examples include coloured pictures, carpets, stained glass, brightly coloured pottery and china, etc. (NOTE.—With modern highly orthochromatic emulsions, very good correction may be obtained for subjects from which reds are absent by using Yellow No. 105 (Iso).)

GREEN No. 401 (BETA)—has a much smaller exposure factor than No. 402 (Gamma) and since it applies a certain amount of correction to all colours, may be used for the same subjects as Gamma where very accurate monochrome reproduction is not required, or where exposure must be kept to a minimum.

GREEN No. 403 (HALF-WATT)—This filter is intended for the photography of brightly coloured objects by artificial light, and

gives a rendering similar to that which would be obtained by using the Gamma filter in daylight.

COLOUR DIFFERENTIATION—INCREASE OF CONTRAST

For subjects of two or more colours, a filter should be chosen of the same hue as the particular colour whose rendering is required to be light in tone. On the other hand, if a darkening of this colour is required, then a filter of the complementary colour should be chosen.

The Micro series of Ilford Filters (with the exception of No. 8) will be found to meet most requirements in contrast work, and is numbered as follows:—

Micro 1	(No. 305 Deep Blue-Violet)
Micro 2	(No. 303 Blue)
Micro 3	(No. 405 Green)
Micro 4	(No. 110 Very Deep Yellow)
Micro 5	(No. 202 Orange)
Micro 6	(No. 501 Purple)
Micro 7	(No. 502 Magenta)
Micro 9	(No. 108 Pale Yellow)

RED No. 204 (TRICOLOUR RED)—this filter will be found useful in addition to the above for such cases as the photography of blue prints, white documents printed in blue, etc.

IMPROVED RENDERING OF DETAIL

In cases where it is difficult to obtain a clear rendering of the detail of the surface structure of a subject, a filter should be employed of the same colour as the general hue of the subject. A few examples of Ilford Filters which can be used in this way are as follows:—

*YELLOW No. 109 (DELTA)—for architectural subjects, especially buildings of Portland stone. In addition to enhancing the details of the stonework, acts as a contrast filter by darkening the tone of the sky.

YELLOW No. 110 (MICRO 4)—for light-toned woodwork, such as fumed oak, satin wood, and many of the paler woods used in modern furniture.

ORANGE No. 202 (MICRO 5—"FURNITURE RED")—for dark oak and walnut woodwork. Also useful for architectural subjects containing brickwork, and for the copying of old and faded paintings, old documents, etc., in which brown tones predominate.

RED No. 204 (TRICOLOUR RED)—for mahogany and other very dark woodwork, and for very dingy paintings.

APPROXIMATE EXPOSURE FACTORS FOR ILFORD FILTERS WHEN USED WITH ILFORD AND SELO PANCHROMATIC MATERIALS

Approximate exposure factors for daylight are given in the first of the following tables. Those for light from average incandescent tungsten lamps, sometimes called gas-filled lamps or half-watt lamps, are given in the second table. The letters NR indicate that the particular filter is not recommended in the circumstances in question.

The average incandescent tungsten lamp is taken as burning at a colour temperature of about 2,850°K.

The column headings indicate the kind of panchromatic material, and a key to the indicating numbers is given below.

Indicating Number	Material
1	H.P.3 Plate F.P.3 Plate
2	Soft Gradation Panchromatic Plate Special Rapid Panchromatic Plate
3	Rapid Process Panchromatic Plate
4	Thin Film Half-tone Panchromatic Plate
5	Fine Grain Panchromatic (F.P.) Roll Film Extra Fine Grain Panchromatic Film (F.P.2) for Leica, etc. Fine Grain Panchromatic Film 16 mm.
6	Process Panchromatic Film
7	Hypersensitive Panchromatic Plate Hypersensitive Panchromatic (H.P.3) Roll Film Hypersensitive Panchromatic (H.P.3) Film for Leica, etc. Hypersensitive Panchromatic Film (H.P.3) 16 mm. Series III Panchromatic Ciné Negative Film 35 mm. H.P.3 Flat Film

APPROXIMATE EXPOSURE FACTORS FOR DAYLIGHT

	1	2	3	4	5	6	7
YELLOW FILTERS							
101 —	1½	1¾	1¾	—	1½	2	1½
102 Aviol	1½	1½	1½	—	1½	2	1½
103 Chromatic No. 1	1½	1½	1½	—	1½	2	1½
104 { Alpha ... ... / Micro No. 8 ... / Chromatic No. 2	1½	1¾	1¾	—	1½	2	1½
105 Iso	1½	2	2	—	1½	2	1½
106 —	1¾	2¼	2¼	—	1¾	2¼	1¾
107 —	2	2½	2½	—	2	2½	2
108 Micro No. 9 ...	1½	1¾	1¾	—	1½	2	1½
109 { Delta ... ... / Chromatic No. 3	2	2½	2½	—	2	2½	2
110 { Micro No. 4 ... / Minus Blue ...	2¼	3	3	—	2¼	3	2¼
111 —	2½	3½	3½	—	2½	3½	2½
ORANGE and RED FILTERS							
201 —	3	4	4	—	3	4	3
202 { Micro No. 5 ... / Furniture Red ...	3½	5–6	6	—	4½	5–6	3½
203 —	4	7	8	—	5	6	4½
204 Tricolour Red ...	4	8	10	—	5–6	6–7	4½
205 —	15	20	20	—	15	15–20	13
206 Micro Nos. 5 + 6	100	150	150	—	100	150	90
BLUE FILTERS							
301 H.S.	NR	NR	NR	—	NR	NR	NR
302 Minus Red ...	4	3	3½	—	3	3	3
303 Micro No. 2 ...	8	5	7	—	5	5	5
304 Tricolour Blue ...	9	6	8	—	5–6	5–6	5–6
305 Micro No. 1 ...	13	9	12	—	9	9	9
GREEN FILTERS							
401 Beta	2	2	2½	—	2	2	2
402 Gamma	3½	3½	4	—	4	4	4
403 H.W.	NR	NR	NR	—	NR	NR	NR
404 Tricolour Green	6	5–6	6–7	—	6	10	4½
405 Micro No. 3 ...	6	5–6	6–7	—	6	10	4½
406 Astra	4	4	4½	—	4	6	3½
407 —	5	5	5–6	—	5	8	4
PURPLE and MAGENTA FILTERS							
501 Micro No. 6 ...	10	10	10	—	10	8	10
502 Micro No. 7 ...	5	5	5	—	5	4	5
503 Minus Green ...	7	7	7	—	7	6	7
MISCELLANEOUS FILTER							
805 Q	1¼	1¼	1¼	—	1¼	1¼	1¼

APPROXIMATE EXPOSURE FACTORS FOR ELECTRIC LIGHT
(Incandescent Tungsten, Gas-filled Lamps)

	1	2	3	4	5	6	7
YELLOW FILTERS							
101 —	1¼	1¼	1¼	1¼	1¼	1¼	1¼
102 Aviol	1¼	1¼	1¼	1¼	1¼	1¼	1¼
103 Chromatic No. 1	1¼	1¼	1¼	1¼	1¼	1¼	1¼
104 {Alpha ... ... / Micro No. 8 ... / Chromatic No. 2}	1¼	1¼	1¼	1¼	1¼	1¼	1¼
105 Iso	1¼	1¼	1¼	1¼	1¼	1¼	1¼
106 —	1¼	1¼	1¼	1¼	1¼	1¼	1¼
107 —	1¼	1½	1½	1½	1¼	1½	1¼
108 Micro No. 9 ...	1¼	1¼	1¼	1¼	1¼	1¼	1¼
109 {Delta ... ... / Chromatic No. 3}	1½	1½	1½	1½	1½	1½	1½
110 {Micro No. 4 ... / Minus Blue ...}	1½	1¾	1½	1½	1½	1¾	1½
111 —	1¾	2	2	2	1¾	2	1¾
ORANGE and RED FILTERS							
201 —	1¾	2¼	2¼	2¼	1¾	2	1¾
202 {Micro No. 5 ... / Furniture Red ...}	2	2½	2½	2½	2	2¼	2
203 —	2	3	3½	3½	2	2¼	2
204 Tricolour Red ...	2¼	3½	4½	4½	2¼	2½	2
205 —	–	18	15	–	–	–	8
206 Micro Nos. 5+6	50	100	100	100	50	50	45
BLUE FILTERS							
301 H.S.	1½	1½	1½	1½	1½	1½	1½
302 Minus Red ...	6	4½	4½	4	4	4	5
303 Micro No. 2 ...	13	10	10	8	8	8	10
304 Tricolour Blue ...	15	12	12	9	9	9	12½
305 Micro No. 1 ...	23	18	18	14	14	14	18
306 —	–	22	43	–	–	–	34
GREEN FILTERS							
401 Beta	1½	1½	1½	1½	1½	1½	1½
402 Gamma	3	3	3	3	3	3	3
403 H.W.	3½	3½	3½	3½	3½	3½	3½
404 Tricolour Green	7	5	4½	6	5	8	5½
405 Micro No. 3 ...	7	5	4½	6	5	8	5½
406 Astra	5	4	4	4½	4	6	4½
407 —	6	4½	4½	5½	4½	7	4½
408 —	–	7–8	9–10	–	–	–	10
PURPLE and MAGENTA FILTERS							
501 Micro No. 6 ...	10	12	12	11	11	9	9
502 Micro No. 7 ...	2½	3	3	2¾	2¾	2¼	2¼
503 Minus Green ...	3½	4½	4½	4	4	3½	4½
MISCELLANEOUS FILTER							
805 Q	1¼	1¼	1¼	1¼	1¼	1¼	1¼

APPROXIMATE EXPOSURE FACTORS FOR DAYLIGHT
(For Orthochromatic Plates and Films)

Material	Aviol No. 102	Chromatic No. 1 No. 103	Alpha No. 104	Iso No. 105	Delta No. 109
ROLL FILM					
Selochrome ...	2½	2½	2½	3	4
Selo Ortho ...	3	3	3	4	–
FLAT FILMS					
Ilford Hyperchromatic	2½	2½	2½	3	4
Ilford Selochrome	2½	2½	2½	3	4
PLATES					
Ilford Press Ortho Series 2 ...	2	2	2	2½	4
Selochrome ...	2½	2½	2½	3	4
Ilford Golden Iso Zenith	3	3	3	4	–
Ilford Iso Zenith	3	3	3	4	–
Ilford Auto-Filter	3	3	3	4	–
Ilford Chromatic	2½	2½	2½	3	4

OPTICAL QUALITY OF COLOUR FILTERS

It cannot be over-emphasized that filters must not upset the definition of the image produced by the camera lens.

Ilford Colour Filters are manufactured from gelatin containing highly purified dyes, in the form of thin sheets or films which in the case of most filters are 0·10 mm. thick. Gelatin film filters intended for use on camera lenses are of excellent optical quality, do not affect definition, and cause no lateral movement of image or change of focus. They are, however, difficult to handle, since contact with the fingers inevitably produces permanent marks, and if they are to be rapidly interchanged it is advisable to mount them in some kind of support, which may be made from cardboard and can be fixed in front of the lens. Alternatively, they may be mounted between the components of compound lenses.

For regular and constant use, it is better to have the filters cemented between glasses. Three qualities of cemented glass filters are available as follows:—

(a) Cemented between specially selected patent plate glass.— These are suitable for use with small short-focus lenses and for less particular work with larger lenses. They cannot, however, be used successfully with very long-focus or telephoto lenses, and they are quite unsuitable for special work such as photo-mechanical reproduction.

(b) Cemented between optically-worked glass.—These are suitable, except in cases where the utmost precision is required, for all general photographic work with the highest classes of lenses, including telephoto lenses. The filters are carefully tested at every stage of manufacture and may be used with perfect confidence. The sharpness of definition obtained approaches that of optical flats.

(c) Cemented between optical flats.—These are precision filters of the highest quality. They are subjected to the most rigorous tests and are specially intended for photo-mechanical and other work requiring the highest accuracy and perfect definition.

MOUNTING FILTERS ON THE CAMERA

As already mentioned, gelatin film filters may be fixed between the components of compound lenses. Glass filters can be mounted either in front of or behind the lens, but the former position is more usual, the filters being carried in special mounts which slip over or screw into the front of the lens barrel.

Great care must be taken to avoid undue pressure on a cemented filter. The least distortion by pressure may completely destroy definition. For this reason, a special fixing device is used on filter mounts supplied by Ilford Limited, so that it is practically impossible to strain a filter when fitting it into its mount.

FOCUSSING WHEN USING FILTERS

As noted above, gelatin film filters have no appreciable effect on focussing. This is true whether they are placed before or behind the lens, or between its components. Cemented glass filters, on the other hand, have a definite though small effect on the image-forming rays, depending on their thickness and on their position with respect to the lens. For general photographic purposes, however, the alteration of focus is negligible when the filter is placed in front of the lens, and for this reason, together with greater accessibility, this is the position in which glass filters are normally employed.

When a thick filter is placed behind the lens, the image is focussed at a point slightly further from the lens than normally and due regard must be paid to this fact when focussing the camera.

CHAPTER V

THE TECHNIQUE OF PICTURE MAKING

SECTION I—THE PICTURE

Graphic art conveys its message in terms of form and tone and in the photograph both are determined by the nature of the image cast by the lens upon the sensitive material in the camera. The picture may be pleasing or otherwise, and this is true even if all the photographic operations have been carried out satisfactorily. It is easy to set down the rules upon which a satisfactory exposing and processing technique may be established—the question of laying down the principles of picture making is another matter.

In later chapters we shall consider matters relating to exposure and development. In this chapter we shall consider first the artistic approach to picture making, and then the camera technique in relation first to types of subject and then to types of camera. According to the objective which a photographer has set for himself his requirements will vary. The snapshotter is usually content with clear pictures; the man who wishes to obtain accurate records makes the camera tell a truthful story; the portrait photographer endeavours to make character speak through the features of his subject, and the pictorial photographer portraying scenes of great charm and beauty, wishes to pass on an emotional experience.

This last purpose may be taken as the aim of every artist, and in this realm no written precept can replace the knowledge which is founded upon an inner awareness developed and clarified by years of observation. Art does not lend itself to analysis, nor can the emotional content of a picture be dissected in terms of physical qualities. But it does not follow that *no* guidance can be given. From careful study of the works of great artists it is possible to arrive at certain principles of arrangement and composition, obedience to which will ensure what may be termed a safe structure for a picture. It is, for instance, known that certain arrangements of lines convey the impression of activity and that certain others are static, but it should be always remembered that a picture manufactured on these lines may have no more emotional content than an engineer's blue print.

The first rule to be remembered for the photographic pictorialist is that simplicity pays. In some ways the very perfection of photographic draughtsmanship is a foe to picture making, as a superabundance of fine detail may distract the eye and the mind from the main object of the picture.

Large masses of tone suitably arranged and balanced give quality and breadth, and for this reason certain artifices, such as diffusion, are used by pictorialists which, whilst meeting with strong objection from some technicians, do permit the pictorial photographer to emphasize or subdue certain parts of a picture to produce the impression he wishes to convey.

A more orthodox technique is the use of a long focus lens to narrow the angle of view which will simplify the problem of finding a picture whose parts fall into a well-knit scheme of lines and masses.

Some of the principles of arrangement already mentioned are given below.

Never divide the picture into two approximately equal parts by a definite vertical or horizontal line. In landscapes containing the horizon, the latter should be one-third of the distance from the top or bottom of the picture. The latter arrangement (two-thirds of sky) is usually preferable and requires that clouds form an essential part of the composition.

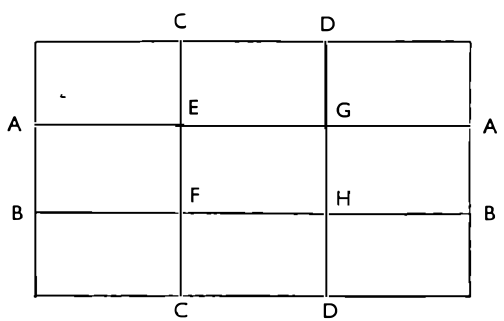


Fig. 56. Strong and weak places in composition.

Keep the margins and corners of the picture free from subjects of interest.

Have a leading object of interest, and place it somewhere on the lines AA, BB, CC, or DD (Fig. 56), never in the centre of the picture.

The points E, F, G, and H are "strong" places in the picture, where an object obtains emphasis.

Avoid symmetry, *e.g.*, the placing of one leading object at H and another at F.

A point of view which brings the highest light against the darkest shadow is often the making of a picture.

In street and other scenes, the V-shaped area of sky is often unpleasing. Try to break up the sky line with some projecting object, such as a chimney or tower.

The eye normally moves across the picture from the main point of interest through the centre until it finds a co-related accent on the other side, so that in place of symmetry we must employ the concept of balance of tone and form. (Fig. 57.)

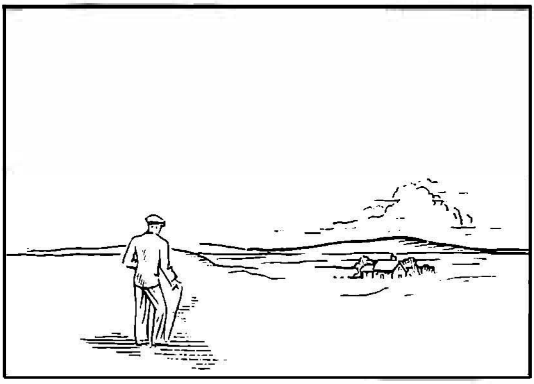


Fig. 57.

This idea of balance applies not only to the placing of the parts within the picture area, but to the relationship between objects situated in the various planes. Balance in a picture is not simply a

Fig. 58.

matter of tone masses but of related interests, and it may be achieved by means of the opposition of lines.

Opposition of lines is demonstrated in the construction formed by the passage of a road, track, or stream, which, beginning at a

suitable place in the foreground runs back into the picture, forming angles in its deviating course, disappearing here and there only to be rediscovered further back, and in this way forming a natural series of oppositional lines in any direction calculated to draw the interest back into the picture. Such lines may be used in the effort to obtain unity in the picture. (Fig. 58.)

It will be seen that the lines provided by a track or stream offer a very good entrance into a picture, though the same effect may be secured by leaving the foreground free from obstruction, so that the eye passes right into the picture straight away. Having obtained entrance, the picture construction should lead the observer's eye to the main point of interest and thence follow an easy route, through a group of trees, for example, to an accent in the sky or to a glimpse of distance.

A favourite device of photographers for allowing free entrance into a picture is the arch or doorway in shadow, with little or no

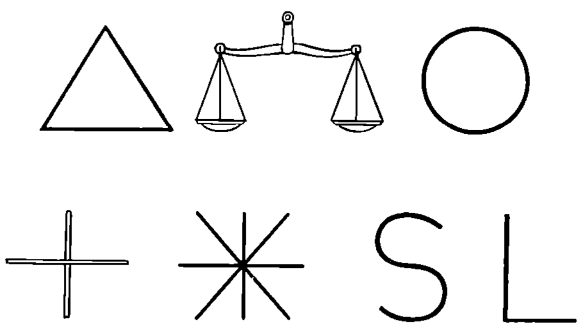


Fig. 59.

detail. Since the eye is attracted more by light than by dark, it quickly passes over the dark tone of the doorway and into the picture where the subject is brightest.

We have already mentioned the possibility of providing skeleton layouts upon which technically satisfactory pictures can be constructed. In his book "Art Principles in Practice," Henry R. Poore gives a series of forms which may be used in this way. These are indicated in Fig. 59.

Any one of the forms may be employed in the construction of a picture, or several of them may be evident in the same picture. The triangle is the most common form of construction; it establishes stability. Head and shoulders in portraiture naturally fall into this figure and many other natural forms, singly and in groups, have their strongest effect when constructed on the principle of the triangle.

Horizontal lines make for placidity, quiescence, and peace. Vertical lines give stability and strength and diagonal lines indicate activity and energy, but require support. Lines may be suggested by a series of incidents or accents of light by means of which the eye is encouraged to travel in a particular direction. Lines which cross the picture completely in any direction tend to take the eye out of the picture and should be avoided unless an opposing force is introduced.

A picture must not appear incomplete or to have some important part of its content excluded. This is not to say that it is not permissible to show only a head and shoulders or even, on occasion, half a head. This is not simply a matter of completeness of physical features—the picture must not leave a question in the mind. For example, foliage entering a picture area from the top with no visible means of support—or growing out of a roof—is unsatisfactory. In the same way a picture which shows a cast shadow but not the object casting it carries with it a feeling of incompleteness and uncertainty.

SECTION II—CAMERA TECHNIQUE IN RELATION TO TYPE OF SUBJECT

LIGHTING OF OUTDOOR SUBJECTS

In outdoor work the direction in which the light falls on the subject is of prime importance. This factor is greatest when the light is that of the unclouded sun, and becomes of less account as the sky becomes covered with clouds, when no definitely shaped shadows are cast. When the sun is shining, the least acceptable lighting, however high or low the sun may be in the sky, is that with the sun directly behind the camera; the subject then has the minimum of relief, owing to the almost complete absence of cast shadows. The lighting with the sun at its zenith, as round about noon in summer, is also unfavourable because of the predominance of short shadows.

As a general rule the best lighting is one in which the direct rays from the sun come from behind the camera and well to the right or left. This direction may be visualized by supposing the subject to be the XII on a clock dial and the camera to be pointed at it from VI o'clock. An ideal lighting will be that in which the sun is to the rear at a point indicated by lines starting at the centre of the dial and passing through IV or VIII. In the case of subjects which are near at hand, *e.g.*, buildings, street scenes, figure studies, this is a sound rule for any hour of the day. For those of an open and more distant character, *e.g.*, open country, panoramas, a low position of the sun in the sky, as in early morning or late afternoon in the summer months, adds enormously to the attractiveness of a scene. Many a landscape is transformed from insignificance to beauty by the long shadows cast at these hours of the day.

But it must not be supposed that a side-lighting from behind is the only one to be aimed at. Most admirable effects are obtained with the sun more or less facing the camera, that is to say, in a position denoted by lines passing through XI or I o'clock (according to our previous example), or even directly in the line of sight provided the sun is not actually included in the picture. Such *against-the-light or contre-jour* effects add immensely to the charm of sea or lake scenes, snowscapes, and also of many nearer subjects—street scenes, figure studies. But remember that in these circumstances the lens should be shielded against direct rays from the sun by means of a hood, and that a backed plate or film should be used for prevention of the halation which otherwise is liable to occur.

When the entire sky is lightly or heavily clouded, so that objects fail to cast defined shadows, the above maxims almost cease to apply, yet under such conditions it is well to try to take advantage of any extra brightness there may be in part of the sky. When there is mist, haze, or slight fog, a panchromatic film or plate, in conjunction with the Ilford Delta or Micro-5 filter will produce negatives having satisfactory contrast, and in this way results may be obtained under conditions which might otherwise be considered hopeless.

Outdoor photography under conditions which would normally make the production of a negative impossible has been rendered quite practicable by Ilford Infra-red Plates. The sensitivity of these plates to infra-red rays is such that the image on the negative may be formed entirely by them, and advantage thus taken of their property of passing through mist which partly absorbs and partly scatters rays of shorter wavelength. The short waves are prevented from reaching the plate by placing an appropriate filter in front of the lens. By this means subjects at a very great distance—so far as to be hidden by atmospheric haze—may be photographed with remarkable clarity.

DISTANCE OF VIEW-POINT

It cannot be too strongly emphasized that many outdoor subjects are rendered in more pleasing perspective by using a lens of much greater focal length than that usually supplied with the camera, *e.g.*, about 8 in. for a half-plate camera. Particularly in the case of subjects, such as streets and lanes, in which the lines run almost directly away from the camera, the lens of relatively short focus dwarfs the more distant part of the subject and gives a false effect of width and space to the foreground, whereas a lens of about 15 ins. or more focal length, when used for a half-plate and with the camera at a greater distance, renders the scene more nearly as one is accustomed to see it. As already mentioned (p. 9), this difference is due solely to the point of view. If both lenses are used from the same standpoint, and the negative (or rather the appropriate part

of it) taken with the shorter focus be enlarged to the same size as that taken with the lens of longer focus, the "drawing" will be identical.

The photographer should keep in mind, therefore, that there are two ways of making the picture larger on the ground glass: (1) going nearer to the subject, and (2) using a lens of longer focus—and that as a rule the second way is the better.

VIEW-POINT

The distance of the view-point from the subject having been decided on and its position approximately settled, the final arrangement of the picture calls for close scrutiny of the image in the view-finder or on the focussing screen, if the camera possesses one. A distant tree, for example, may be so placed that it appears to be growing out of a cottage chimney; a post in the foreground may block out part of a winding path in the mid-distance. By moving the camera a few feet to right or left these unfortunate relationships may be avoided.

MOVING OBJECTS

In photographing subjects which include people, etc., in movement, it is obvious that the images of the moving persons move to some extent on the sensitive film and thus become more or less blurred, however short the exposure. Hence the necessity for making the time of exposure so short that the amount of blur is imperceptible in the print or enlargement. Pages could be filled with rules and formulæ for ascertaining the permissible time of exposure according to the distance and rate and direction of movement of the object and focal length of the lens. They would be of little use in everyday work, and the amateur can be given guidance in a much simpler way.

With a great number of the cheaper hand cameras, the shutter, fitted in or near the lens, cannot give a shorter exposure than 1/100th of a second, while many are limited to 1/50th of a second. Yet this top speed is fast enough for a very large proportion of the subjects with movement which most amateurs take, such as town scenes with pedestrians or slow horse or motor traffic, seaside studies of children and bathers, rural life, animals in zoos, and so on. With such subjects, 1/100th or even 1/50th sec. will give satisfactory sharpness provided some degree of care is exercised in choosing a point of view such that there is minimum of image movement on the film or plate.

The important thing to remember is that the moving object causes the least blur if snapped as it makes nearly straight for the camera. If taken as it crosses the field of view at right-angles, the exposure requires to be one-third at most of that for the end-on direction, other things being equal. A line of approach at a slight angle (about 30°) to the end-on course gives a better view of a vehicle or

rider and represents a compromise which comes within the scope of the fiftieth or hundredth of a second exposure.

Sports such as tennis, running, jumping, horse and motor racing, and subjects like railway trains and speed-boats, require shutter speeds ranging from 1/150th to the highest speed of the focal-plane shutter, which, engraved marking notwithstanding, may be put at about 1/600th sec. A focal-plane shutter is essential for these fast-moving subjects, and with it, too, the factors of direction and distance of the object, as explained in the preceding paragraph, must be taken into account. In theory, the focal-plane shutter should frequently give distorted photographs of objects in rapid motion owing to the exposure of the plate in successive bands as the slit of the shutter travels across it. Actually, examples of such distortion are rarely seen, since the pressman's focal-plane camera can be used so that the slit in the blind travels in the direction opposite to that of the image of the moving object. This means that when viewed in the finder the object should move in the *same* direction as will the shutter blind when released; the *image* of the object moves in the reverse direction.

An item of vital importance in photographing many subjects in rapid movement is that of deciding the instant at which the shutter is to operate. This moment of decision has to be a little in advance, for there is the distinct lag of the nerves in carrying out the order of the brain, and also a certain interval of time between the pressure of the button and the uncovering of the plate. In the absence of allowance for these two delaying factors, the rushing car or leaping greyhound, seen full in the line of sight when the release was pressed, may be found to be entirely missing from the negative.

For certain fast-moving subjects, like motor cars and cycles, which do not include rapidly moving parts, as do runners or hurdle racers, a dodge for obtaining a sharp picture at close range with a moderate shutter speed is to follow the subject with the camera during the exposure. This is done by swinging the whole body from the hips, keeping the camera level. The result of this trick is to draw out objects in the background into an indistinct blur, which, far from being a drawback, imparts a sensation of movement to the subject proper. By this ruse a shutter speed of about 1/50th sec. may be used with striking success for subjects which in the ordinary way would come out blurred if exposed for a tenth of the time.

ARCHITECTURAL INTERIORS

Interior subjects of this description usually require considerable care, and the use of the stand camera, or at any rate of a camera which allows arrangement of the picture and of focussing on the ground glass, is undoubtedly of considerable assistance. Many interiors require the use of a wide-angle lens in order to include as much of the subject as is desired, but as far as possible the use of

such a lens should be avoided, since its effect is to give an exaggerated perspective in which the foreground is too prominent, whilst pillars and columns in the margins of the picture are spread out in width and to oval shape—often to a ludicrous degree. Much can be done to obviate this effect by correct choice of position. In the case of churches and cathedrals a position of the camera well to one side or the other of a nave or transept will bring one of two rows of columns nearer to the middle of the picture (where the spreading effect is much less marked), whilst the columns of the other row are rendered one behind the other, and so are suggested, though not recorded, as the counterparts of the columns on the opposite side. A central standpoint of the camera is the worst for church interiors in which there are columns on either side. In small interiors, such as drawing-rooms, care should be taken to keep articles of furniture from the edges, and especially the corners of the picture. Also the immediate foreground should be free from prominent objects, which would dwarf other parts of the subject. In all use of a wide-angle lens, the aim should be to place the camera so that as much of the subject as possible is presented flat to the lens—not protruding towards or receding from the lens.

Although sunshine may often be used with admirable effect for an interior subject, the best result as a rule is obtained when the outside lighting is that from a lightly-clouded sky. The illumination of the dark parts of the subject is then better, and the range of luminosities—from a lighted window to the deepest shadow—is more nearly within the capacity of the plate. In interiors of small size, where there are exceptionally dark shadows in which detail is required, it is of great advantage to provide some extra illumination by fixing a flash bulb or a little flash-powder a few yards from the shadowed portion, taking care, however, that the actual flash is not in the field of the lens.

In examining an interior subject on the ground glass the full aperture of the lens is used, but a smaller stop, *e.g.*, *f*/16 to *f*/32, is nearly always required for obtaining foreground and distance in sharp focus. A magnifier is usually necessary for examining the dim image, otherwise it is impossible to see whether it is sharp. With very dark subjects, the help of a friend holding a pocket torch in the field of view at different distances from the camera enables focus to be checked with certainty.

Halation (see Chapter III) is the bane of interior photography, but can be almost entirely prevented by the use of backed plates or film. At the same time much can be done to arrange matters so that there is less liability to halation. In large interiors actual sunlight on windows should be avoided, whilst in those of small size, windows which are included in the photograph may be covered during the greater part of the exposure by drawn blinds or by hanging up a curtain. The window should then be uncovered and

a second short exposure given. With subjects in which an outside scene is in view through the window, this expedient enables the outside vista to be effectively included in a photograph sufficiently exposed for the interior.

In all interior work, perfect cleanliness of the outer and inner surfaces of the lens is essential. Neglect in this respect can often give rise to veil or effects resembling halation.

The exposure to be given for an interior subject may be anything from a few seconds to several hours, owing to the enormous differences in illumination. Experience alone can teach, but it is always well to err on the side of over-exposure.

SUBJECTS WHICH REFLECT

Numerous objects of different character have polished surfaces in which surrounding articles are reflected, which give rise to the occurrence of irregular markings which greatly disfigure the photographs and cannot be readily touched out on the negatives. Such objects include shop windows, varnished paintings and pictures under glass, motor vehicles and polished furniture, glass and silverware. In few cases can anything be done to dull the polished surfaces, when the reflecting object does not constitute an important part of the picture it may be hidden by means of a screen of some kind, and sometimes the lighting may be arranged in such a way that reflection is reduced to a minimum. When judging whether reflections will spoil the negative, it is not sufficient to examine the image on the ground glass; the subject itself must be scrutinized from a position in front of the camera so that the eyes are as nearly as possible in the place of the lens.

A method which may be of advantage in some cases is to make the exposure with an ultra-violet absorbing filter, such as the Ilford " Q," on the lens.

Shop fronts are among the most difficult of these subjects. In daylight, ordinary methods are usually hopeless unless the shop is strongly lighted and the opposite side of the road is in shade. Even then there will be some reflection, and as any screen behind the camera is out of the question in a busy thoroughfare, the method normally adopted is to photograph the window at night (when there is no street lighting) by its own illumination and to make a supplementary exposure for the facia and outside of the building by flashlight or possibly in daylight. Plates and films of the hypersensitive panchromatic class have done much to simplify artificial light work.

With paintings and pictures under glass, which frequently cannot be moved from their places in galleries, a curtain of black sateen, or several of them, can be hoisted on bamboo sticks behind the camera to screen off objects which would be reflected. Often a slight tilt of the painting, arranged by stuffing a newspaper behind

the frame, will be enough to shift a reflected patch of light wide of the camera. Furniture, when photographed in the maker's workshops, can likewise be fenced round with screens of butter muslin, which admit plenty of light yet offer no definite shape which may be reflected by the polished wood or by such items as wardrobe mirrors.

Small articles of silver or glass call for slightly different treatment. Reflection patches of definite shape must be prevented, and yet these goods must be shown as having a lustrous or shining surface. This is done by arranging them in a skeleton tunnel, open at each end and covered with butter muslin or tracing cloth. This miniature studio of, say, 30 × 30 in. section and 20 in. length, may be moved about in a room or studio to secure a soft even lighting, and then a high-power gas-filled lamp can be brought up to one side of the tunnel, or the far end (through a thickness of muslin), to give the strong accents of light. Some workers chill articles of silver so that they become covered with condensed moisture. Others use various pastes designed to minimize reflection.

ELIMINATION OF REFLECTION BY MEANS OF POLARIZING FILTERS

Troublesome reflection may often be dealt with simply and satisfactorily by means of polarizing filters. Like an ordinary colour filter the polarizing filter exerts a selective absorption on light

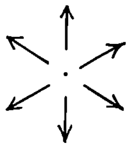


Fig. 60.

passing through it, but unlike an ordinary filter it takes no notice of colour, but of an equally fundamental quality of light. As we have seen, light can be considered as a transverse wave motion or vibration in the ether and the vibrations which accompany a ray of light occur in all possible directions at right-angles to it. Thus, looking down the ray, the vibrations could be represented by the arrows in Fig. 60.

If now, the light is made to pass through a Nicol prism or through a polarizing filter all the vibrations are absorbed except those in one particular plane which is determined by the position of the filter, with the result that a sort of knife-edged beam with the vibrations all in one plane is produced; this is known as the plane of polarization. It is as if the filter consisted of a number of parallel plates lying close together and presenting their edges to the light beam. Only vibrations in a direction parallel to the parallel plates could possibly get through.

If the beam is made to traverse a second prism or a second polarizing filter this also will exert the same selective action, and if the vibrations remaining after passage through the first filter are in the correct plane to pass through the second, no further absorption will take place. If, on the other hand, the second filter is so positioned that it can only transmit vibrations at right-angles to those remaining after passage through the first filter, then the combined action of the two filters will be to absorb all the light completely. In this position the filters are said to be crossed. If the second filter is so set that its plane of polarization is not quite at right-angles to that of the first filter, it will absorb part of the light passing through the first filter.

To polarize light it is not necessary to make it pass either through a Nicol prism or a special polarizing filter. The fact is that the specularly reflected light which is so troublesome to photographers is itself very often polarized, whereas the image-forming rays reflected from the subject in the ordinary way are not polarized. In such circumstances, it can easily be seen that a polarizing filter placed over the lens and set with its plane of polarization at right-angles to the plane of polarization of the specularly reflected light, will provide a means of eliminating the unwanted reflections. Polarizing filters exertsome general absorption, and so their effective density is greater than would be expected from the polarizing effect alone. This must be taken into account when determining the filter factor.

Unfortunately, the specularly reflected light is not completely polarized and the extent to which it is polarized depends upon the angle of reflection. For water, glass, and most of the common reflecting substances, the polarization is nearly complete for rays coming from the reflecting surface at angles between 32° and 37°, and so the technique described is effective only when a very oblique representation is satisfactory. There is, moreover, an important exception in the case of *metallic* surfaces, the specularly reflected light from which is not plane polarized and so this straightforward method of attack with one filter cannot be practised. In this case, and generally when we wish to have the greatest control over reflection, the two-filter technique is employed, and use is made of the fact that polarized light which strikes upon a diffusely reflecting surface is de-polarized. Now, if we polarize the light at the source all that part of it which is reflected from the subject in the ordinary way will be de-polarized whilst the specularly reflected light will remain polarized. In this condition it can be, of course, got rid of by the filter on the lens mount.

Further practical information is given in the following notes:

If one filter only is used, this must be placed over the lens of the camera, and the direction of lighting and the positions of subject

and camera must be so chosen that the light in the reflections is plane polarized.

When the angle between the axis of the camera and the reflecting surface is between 32° and 37° the effect is most marked; at smaller or greater angles the effect is less, disappearing entirely for right-angled reflection or for grazing reflection. It is, however, difficult and unnecessary for the photographer to estimate the angles at which all the reflecting surfaces lie in a given subject. Instead he can observe the effect of the filter directly for himself either upon the focussing screen of his camera, or failing this, by looking through the filter itself at the subject. The filter is rotated slowly until the best effect is obtained; the position of the marks on the periphery of the filter is noted and the photograph is taken with the filter marks in this position.

For subjects which show reflection at only one surface or group of similarly placed surfaces, it is usually possible to select a camera position from which the polarizing filter can subdue the reflection to any desired extent. On the other hand, when the reflections come from very different angles it is not possible, merely by placing a polarizing filter over the lens, to suppress all of them at once.

If two filters are used, one is placed on the camera as before and the other, which must be much larger, is placed over the light.

This arrangement enables one to maintain a much greater control over reflections than before, because the illuminating light itself is polarized before striking the subject. Thus it is possible to subdue reflections from every angle and from all glossy surfaces, including those of polished metals. But complete suppression is not always possible, even with this arrangement.

The method consists in turning one or other of the filters until a satisfactory result is obtained. With the filters fully crossed, the maximum subduing effect is obtained, while with the filters in the parallel position the reflections are enhanced. Between the two positions any desired control of the reflections is available.

When the two-filter technique is used it is necessary to ensure that no part of the subject is lit by stray light which may have become de-polarized by reflection from walls, etc. Such light could, of course, give rise to reflections over which the camera filter would have no control.

INDOOR SUBJECTS BY ARTIFICIAL LIGHT

At one time cameras came in and out with seasonal regularity, and photography other than by daylight was a thing unheard of excepting by the professional photographer, who by reason of his expensive and elaborate lighting equipment was able to work by artificial light. Now, however, with fast plates and films and fast lenses photography is an all-the-year-round activity and with

Fig. 61. This Floodlight is designed for use either as a studio auxiliary or for home photography. It is of very robust construction, having a heavy base and rigid stand. It can be used either on a table or on a wall and is provided with simple directional control. It has a matt silver reflector which gives a uniform light free from shadows and it is fitted with a handy switch with flex and plug. It will be found to be an invaluable accessory for studio or home photography.

Fig. 62. The Selo lighting set is an indispensable aid to indoor picture-making at night. It gives maximum efficiency and is so ingeniously constructed and balanced that there is almost no limit to the number of positions and angles in which it can be used. The reflector is of anodized aluminium and consists of eight hinged facets diffusing a high-intensity light evenly over the entire subject. A light wrought-steel stand gives rigidity and is adjustable to any position so that the set may be used from the floor, a picture rail, the back of a chair, or any other means of support available. Complete with one Photoflood lamp, flex, and universal connecting plug.

modern high-efficiency lighting units available at reasonable prices the amateur photographer can be as busy indoors as out—in artificial light as in daylight. Indoors he at least has complete control over his lighting and can place it where he will.

Subjects are too numerous to mention individually, but he may set out to photograph articles of furniture, to copy pictures, to make table-top photographs, or portraiture itself may claim his attention. Some of these classes of work have already been described and here we shall confine ourselves to portraiture and table-top work.

PORTRAITURE

In portraiture, as with pictorial work, we are concerned with elusive things and qualities. Here technical excellence will not suffice, as if the representation is superficial the result will be readily apparent and it will fail in its emotional appeal. Given artistic insight, the camera portrait may be as satisfying a study as any work from the painter's brush. There is, of course, the need for a sense of balance of form and tone and a knowledge of the different forms of lighting and their arrangement. Rigid adherence to set rules cannot ensure success and for this reason they must never be followed unthinkingly. It is possible, however, particularly with lighting and its arrangement to give useful guidance which may form a basis for experiment.

The artificial light sources available for the portraitist include:—

(1) The tungsten filament (half-watt) lamp normally run and overrun.
(2) The carbon arc open and enclosed.
(3) The discharge lamp of different types.
(4) The flashbulb.

Of these, only 1 and 4 can be considered as available to the amateur. Flashbulbs, except in expert hands, do not lend themselves to pleasing portraiture and so the tungsten lamp is left as the practical source. Nearly all amateur portraiture is done with the overrun tungsten lamp. The professional uses mainly high-powered tungsten lamps.

As we have seen in Chapter IV, much research has recently been carried out on discharge tubes and these are in use in some studios, sometimes in conjunction with gas-filled lamps. Some lamps have actually been marketed in which tungsten and discharge elements are combined in one unit. Arc lamps are used occasionally. As we have seen, they give a light of high-colour temperature, but for studio work they have many disadvantages.

Lamps may be allowed to illuminate the subject directly, after passing through diffusing screens, or after reflection from a suitable surface. They may also be focussed upon the sitter by means of a lens system.

Generally speaking, the lighting system adopted for portraiture must comprise two parts—1, a high-power main light to give modelling, and 2, a broadly diffused general light (known as the flood) to light up the shadows. The first used alone will produce hard chalky portraits; the second used alone will produce flat and featureless results—even if enough light can be obtained in this way to make adequate exposure possible. By combining these two types of lighting units and by using intense focussed spots for special purposes very pleasing effects can be obtained. The modern studio is equipped with overhead banks of lamps running on rails, vertical banks, diffusing screens of various types, and reflectors as well as special units for the production of the main beam. There is, however, no need for anything like such a complete outfit when occasional family portraiture is to be attempted and even quite ambitious work can be done with one or two Selo Floodlights or Lighting Sets in conjunction with the general diffuse room lighting. The portrait illustrations on pages 126-129 are well worth careful study, as they show how by light control the facial appearance of the subject can be changed. The principle is the same whatever the amount of light employed and the illustrations, although made in a professional studio, will serve as a guide for your own work.

Several fairly easily arranged lightings are also illustrated in this chapter and useful hints for successful home portraiture will be found embodied in the captions.

FURTHER POINTS ABOUT PORTRAITURE

In order to secure good drawing and to prevent distortion of features the camera should be at least 7 or 8 ft. from the subject. Even this distance would be considered too close by most professional workers, who would prefer to work at, say, 10–15 ft. However, in many rooms 8 ft. is the greatest distance which can be managed and only rarely is distortion sufficiently great to be noticeable. The longer the focal length of the lens the bigger the image, of course, but if the image is too small the negative may easily be enlarged, so even if you have only a short focus lens this is no very serious disadvantage. The walls should for preference be light in colour to give the maximum reflection and to allow of short exposures. The ordinary room lighting may be used if supplemented with photo-flood lamps in suitable reflectors. Unobtrusive backgrounds are usually to be preferred and these may be contrived in various ways, but often if the subject is placed some distance away from the wall the out-of-focus wallpaper presents a pleasing background.

It is undesirable to have the subject placed too squarely to the camera, but excessively thin persons should not be photographed in profile. Thinly covered heads should not be lit from above and

short-necked subjects should always be taken from a low viewpoint.

Finally, there are two points which it is well to remember. A head placed high in the picture gains dignity; one placed low with plenty of space above it gains in daintiness.

TABLE-TOP PHOTOGRAPHY

In table-top photography the creative impulse can have full expression. Miniature figures, models and useful accessories like Plasticine, Cellophane and tinfoil can be obtained almost anywhere at trifling cost and with these and innumerable other accessories which the photographer can invent for himself there are no limits to the work which may be undertaken. Again, there are no rules, but certain maxims may well prove worth the study.

First of all, it is essential to adhere to a single motif. To place a caricature figure in a realistic setting is to commit the photographic equivalent of mixing a metaphor. Secondly, one part of the picture must not give the lie to any other part. For example, a sunlit scene out of doors will fail to convince if the lighting has obviously come from two different directions, or from a position where the sun could never have been. Thirdly, even in caricature a correct scale must be maintained, unless there is some good reason for falsification. Fourthly, it is well to imitate the good conjurer in hiding the mechanism of the effect. Fifthly, the ordinary principles of composition must be borne in mind.

The illustrations in this section give some impression of the types of subjects which may be attempted.

Table-top photography involves working at close quarters in order to get a large sized image on the plate and this means that the bellows of the camera must be capable of greater extension than is necessary in everyday amateur photography where the distance from the subject to the camera is usually in the neighbourhood of from 10 ft. to infinity. We are now considering the photography of small objects at distances sometimes of only one foot, and for this reason a camera with a double extension will be found to be a great asset if not a necessity.

The field and reflex types of camera, with double extension, are ideally suited for the job as they both have large focussing screens on which the building up of the picture can be constantly watched.

Generally speaking, small lens apertures will be absolutely essential in order to get sufficient depth of focus when working at distances as close as one or two feet. For instance, in the illustration entitled "Night Express," the depth of focus to be rendered in sharp focus was nearly as much as the extension in the camera and, consequently, the smallest available stop was used and the appropriate increase in exposure given.

Occasions arise, however, when the centre of interest has little or no depth and when the background is best out of sharp focus. In cases like this a much larger lens aperture may be used with, of course, a relatively shorter exposure time.

Exposures run into several minutes and great care must be exercised to ensure that the camera is securely held on a rigid support. A bulky but firm stand is much better than an unsteady, light one, and if the stand is fitted with a tilting head it will be easy to get the best angle with the minimum of adjustment.

The lighting technique adopted will make or mar the picture in this branch of photography as much as in any other and must be regarded, therefore, as being of paramount importance. The types of lights and the angles at which they are used for illumination must be carefully considered if the correct "atmosphere" is to be obtained. For example, to get a midsummer effect the dockland set, "Leaving Port," page 142, was illuminated with a "Nitraphot" (500-watt) type of lamp in an aluminium reflector of 11 in. diameter adjusted at an angle of about 65° to keep the shadows short. An opal lamp of much less intensity (100 watts) was placed on the opposite side to relieve any dense shadows.

The illustration "H.M.S. —" (page 138) is an example of dawn or sunset lighting where the primary light is placed in a position to give low angle back lighting. The type of light chosen for this effect was a spot light, moderately diffused with two thin sheets of tissue paper. Only a suggestion of shadow detail is wanted for this effect and is best obtained by placing a white reflecting surface very near the model and facing the light, taking care, of course, to see that the view from the camera is not obscured in any way. Instead of a reflecting surface, a bulb of much less intensity may be used and moved backwards and forwards until the desired effect is obtained.

Lights should be as adjustable as possible and the various effects which the same light is capable of giving according to the manner in which it is masked or diffused are well worth noting and remembering. Ground glass, opal glass, paper tissue, and butter muslin all make excellent diffusers, but when using photoflood bulbs, the last two mentioned should be avoided owing to the risk of scorching.

Reflecting surfaces are sometimes very useful for getting trick effects. In photographing the "Night Express" (see page 141) where the effect of night lighting meant keeping the lights used within strict limits, the shadow cast by the "open" firebox was obtained by means of a small hand mirror placed behind the pile on the right-hand side and illuminated by means of an independent beam in such a way that the light did not obtrude upon the general lighting of the set.

In addition to the usual handyman's tool kit found in almost every house, the beginner will find the following list of articles very useful: Pins, Seccotine, nails, plywood or cardboard for baseboard, a good assortment of papers and card, thin batten, razor blades, Plasticine, thread.

Some simple materials by means of which convincing illusions may be obtained are indicated in the attached list:—

Appearance or Object to be Simulated.	*Material and Manipulation.*
Snow	Salt.
Cloudscapes	Enlargements from cloud negatives or cotton wool pulled apart and mounted with small dabs of Seccotine on a sheet of Cellophane stretched on to a frame.
Cement or concrete ..	French grey distemper.
Pathways and roads ..	Sifted sand which has been dried by baking. Paint a very thin solution of Seccotine over exact portion representing the path on the ply, card, or paper acting as a foundation. Then pour sand liberally over the wetted portion and tip off the surplus. The sand will only adhere to the path area.
Sea at dawn or sunset..	Muranese glass or dry-mounting tissue back lit (*see* picture of "H.M.S. —," page 138). The mounting tissue gives the smoothest effect.
Smooth sea in midday light	Dry-mounting tissue or plain brown paper or linoleum.
Surf from ship's propellers	Soap lather applied with artist's small paint brush.
Locomotive smoke ..	Cotton wool supported on piece of thin wire held in position by small piece of Plasticine in funnel.

Before leaving the subject, mention must be made of another fascinating table-top method, *viz.*, the glass-top technique of which Mr. E. Heimann is the acknowledged master.

Here the objects are allowed to lie on a sheet of glass suspended only at the corners and some considerable way from the background. The camera is pointed downwards upon the models and all sorts of artistic effects may be obtained. By working at $f/4{\cdot}5$, for example, and focussing sharply upon the sheet of glass, only the models will be sharply rendered. For more ambitious work several sheets of glass slightly displaced may be used and variations may be introduced by the use of transmitted light.

SECTION III—CAMERA TECHNIQUE IN RELATION TO TYPES OF INSTRUMENT

HAND-CAMERA WORK

Next to the choice of the view-point in relation to the subject and the lighting, success with the hand-camera depends on the taking of negatives which actually include the subject aimed at, are sharp and are fully exposed. Guidance in these matters is given in the booklets of instruction supplied by the camera manufacturers, but we may give some hints on the points of chief importance.

THE VIEW-FINDER

The picture seen in the finder of almost every hand-camera is so small that it is often difficult to judge if the desired amount of subject is included. A finder-magnifier which shows the picture considerably enlarged is a useful accessory. This device has the further advantage that it positions the eye correctly. In taking portraits or other close-up subjects, the beginner should not be misled into thinking that even if the head of the subject looks small in the finder it will be of satisfactory size in the negative. The user should accustom himself to judging the appearance in the finder by the size of a head or figure relatively to the whole area of the finder picture. Whenever possible, it is well to use a direct-vision frame finder, if the camera is fitted with one, since it allows a much better sighting of the picture. With close-up subjects, the fact that this type of finder must be used at eye level is a drawback which may be offset, however, by stooping or kneeling so as to bring the camera level with the subject. The finder usually ceases to indicate correctly if the lens of the camera is displaced from its central position, and allowance must be made for this unless the camera is one of the very few which incorporate an automatic adjustment.

Focus with Hand-camera

With a camera of fixed focus, the distance beyond which all objectives are in focus is about 15 ft., and it is not at all difficult to become familiar with this one distance. A smaller stop can be used for nearer objects. In using cameras with focussing scales, there is nothing for it but to practise judging distances by eye, bearing in mind that it is the shorter distances, 6 to 15 ft., for which accurate judgment is of chief importance; an error of a foot or two in the estimation of 25 or 50 ft. makes very little difference. The way to practice is to approach some object, such as a lamp-post, to halt when at an estimated distance of, say, 10 ft. and then to check the estimate by pacing out or measuring. Regular practice in this way will soon give proficiency. It is well to select for this exercise only three distances, say 6, 10, and 15 ft., or a similar series according to the scaling of the camera, and it should be borne in mind that judgment acquired by practice in more or less confined situations

such as in streets is apt to be misleading in more open spaces where the tendency is to under-estimate distances.

Holding the Hand-camera

Camera shake during exposure is bound to cause unsharpness, unless the shutter is working at a high speed. The smaller and lighter the camera, the less easy is it to hold it steady for exposure. Fortunately, miniature cameras are usually fairly heavy and their design normally makes for comfortable holding. Even so, a great deal of unsharpness is directly traceable to camera movement, and it is always a good plan to avail oneself of any solid support for the camera or one's body. Failing that, the camera should be pressed firmly against the body, but not with a tight grip, and the breath held when making the exposure. If the exposure is made by pressing a trigger, the hand which is free should support the camera in the direction opposite to the movement of the trigger, so as to counteract the tendency to move the camera, which is involved in the operation of even a lightly mounted shutter trigger. In the use of small box or folding cameras, about 1/25th sec. is the longest exposure which most people can give without shaking the camera while the shutter is open. When big enlargements are contemplated it is well not to go beyond 1/50th sec. With cameras of much greater size and weight, such as quarter-plate reflex, or press camera, 1/10th sec. can easily be given, or as long as 1/4th sec. by those of steady hand.

THE MINIATURE AGAIN

As always, the miniature must be considered separately. First and foremost it is a precision instrument and must be handled as such. It has made wide aperture lenses generally available and a particular feature of many of these cameras is the inter-changeability of lenses so that with one camera the photographer may use a veritable battery of lenses of long or short focus, telephoto or wide angle, and so on. It uses small film so that a number of shots from different view-points may be made without undue wastage and expense. Instruments are generally provided by means of which correct estimation of distance may be made and sometimes these are directly coupled to the focussing device. Generally speaking, it is used at eye level with a direct type of finder which makes picture composition simple and sometimes range-finder and view-finder are one. Film transport and shutter mechanisms are coupled, so that two exposures on one film are impossible. Exposure counters are provided so that at each moment one knows how much unexposed film remains in the magazine. The shutter mechanism is usually operated by means of a release button and as with all releases, care must be taken to avoid camera jerk when the button is pressed. It should be squeezed rather than pushed—the action being similar to the operation of a gun trigger. Shutter speeds of 1/50th or less

are advised. For further details the reader is advised to consult the literature issued by the various manufacturers.

THE REFLEX CAMERA

The many and very positive advantages of a reflex camera have already been briefly outlined and the beginner can be assured that there is no better way to achieve success in hand-camera photography than that which begins with the purchase of an instrument of this kind. In one or two minor respects, however, the reflex is at a disadvantage. When viewing the picture in the usual way by looking into the hood, the camera must be held at waist level—a drawback when it is required to photograph over an obstacle such as a fence or wall or side of a ship. But in these circumstances the reflex user need not be baffled. If the camera can be laid on its side on top of the obstacle, the picture can still be seen and focussed by looking into the now horizontal hood. For this purpose the focussing pinion and release button should be on the same side of the camera. If this is not practicable, the camera may be held upside down at arm's length directly above the head, and the picture viewed by looking up into the hood. Focussing is not an easy operation under these conditions, since both hands are wanted for holding the camera steady, but if a stout carrying strap is fitted to one side, the instrument can be held for a few moments by one hand while the other operates the focussing pinion. It is a tiring business, but then subjects which call for it are exceptional. It should be added that the method is not satisfactory with the type of reflex camera in which the mirror is raised by hand instead of by a spring. A further alleged drawback of the true reflex is that its bulk and shape render it conspicuous and make it difficult to use unobserved, *e.g.*, when seeking to take figure studies unknown to the subjects. If this is found to be the case, a simple way out of the difficulty is to hold the camera with the side against the body and with the lens pointing to right or left. The picture can still be seen and focussed in the hood, and one disarms suspicion by appearing to be photographing something straight in front instead of immediately to one's right or left. The small twin-lens reflex camera taking pictures $2\frac{1}{4}$ in. square on No. 20 film has all the advantages of the true reflex with the bulk reduced to a minimum.

STAND-CAMERA WORK

Setting up the Camera

A steady position is an obvious necessity. The legs of the tripod should be spread out so that the points are 20 to 30 in. apart; if much nearer, the whole erection is top heavy, and the camera is liable to be easily upset. If spread too far apart, the legs are apt to slide on smooth ground. The height of the camera should be adjusted by the sliding lower limb, provided on most wooden tripods, which are by far the best for stand-cameras. For cameras

not of the turntable pattern, the tripod top should be of ample size, at least 5 or 6 in. diameter, or as large as the baseboard will allow. Metal tripods, though highly portable, are not advisable for stand-cameras of any size. The top is usually not larger than 2 or 3 in. diameter and the leg adjustment is not so convenient. Although the contrary is sometimes advised, the best position of the tripod is in Y formation, one leg extending directly to the rear and the other two pointing half-way to the left and right in front. This arrangement is the best for levelling or tilting the camera whilst viewing the effect on the screen.

Level of Camera

If the plane of the sensitive surface is not truly vertical, parallel lines in the subject will be rendered converging to the top or bottom of the finished picture according to whether the surface of the plate slopes away from the subject or towards it. Whilst this distortion does not become evident in landscape and many other subjects, it is fatal when photographing buildings, machines, paintings, etc., which include parallel lines, unless it has obviously been done for effect. The camera is readily set level in both of these respects by adjusting the back leg of the tripod, and the correctness of the adjustment is ascertained, as regards level, by means of a spirit level, fitted on the top of the camera back parallel with the surface of the plate, and, as regards uprightness, by a level similarly fitted but at right-angles to the surface of the plate. Two spirit levels in one mount of T pattern are sold for this purpose and should be fitted to every camera.

Use of Rising Front and Swing Back

More often than not, when the camera is adjusted with the baseboard horizontal and the plate therefore vertical, too much foreground is included, and the upper part of the subject is out of the picture. By raising the lens on the camera front, the image on the screen moves up, cutting off part of the foreground. If, however, there is too little foreground, as when using the camera from a height above the subject, the lens is lowered on the camera front to give more. In either case the lens is no longer opposite the centre of the plate, and is called upon, therefore, to cover a wider angle than normally. Most lenses of moderate aperture (*f*/6 and smaller) will cover plates so much larger than those for which they are listed that there is a margin of covering power ample for the use of the rising or falling front. With lenses which fail to cover even when dropped down, or when the lens is decentred to an extreme degree, the plate can be brought within the normal angle of covering power by making use of a movement provided on many stand-cameras, *viz.*, the swing front. By tilting the raised lens very slightly upwards its axis is brought to the centre of the plate, but no longer at right-

angles to the latter as previously, so that a smaller stop is required for obtaining sharpness all over the plate.

Tilting the whole camera has the same effect of cutting out excess of foreground, and is often necessary when photographing tall buildings with a camera of limited rise of lens. When this is done the swing back *must* be brought into play to restore the plate to the vertical. Here again the lens axis is no longer at right-angles to the plate, and a smaller stop must be used to obtain sharpness over the whole field. If the lens is of ample covering power at its full aperture, a larger stop may be used under these conditions by swinging the lens front vertical, *i.e.*, parallel with the plate. This adjustment utilizes the tilt of the camera for bringing the lens into a raised position relatively to the plate, whilst keeping plate and lens-panel parallel.

The foregoing description covers the principles to be observed in the use of the various camera movements. As already mentioned, these adjustments are of less importance and are generally ignored in the case of landscape and other subjects which do not include manifestly straight lines in their composition.

Swing Back for Depth of Focus

The swing back is frequently useful for an entirely different purpose, *viz.*, so to dispose the focussing screen, and afterwards the sensitive surface, towards the lens that parts of the subject at widely different distances are obtained in sharp focus at a larger lens aperture than otherwise could be used. An example is a view taken across a river with figures in the foreground on the near bank, passing traffic in mid-stream and buildings on the opposite side. In the lens image, formed on the ground glass, the distant part of the subject is recorded in front and the near part behind the sharply focussed image of the mid-distance, with consequent blur of their images. If, however, the ground glass is swung from the bottom away from the subject, its surface comes more nearly into the position of sharp focus of the various planes of the subject, the lens thus requiring less stopping down for satisfactory definition.

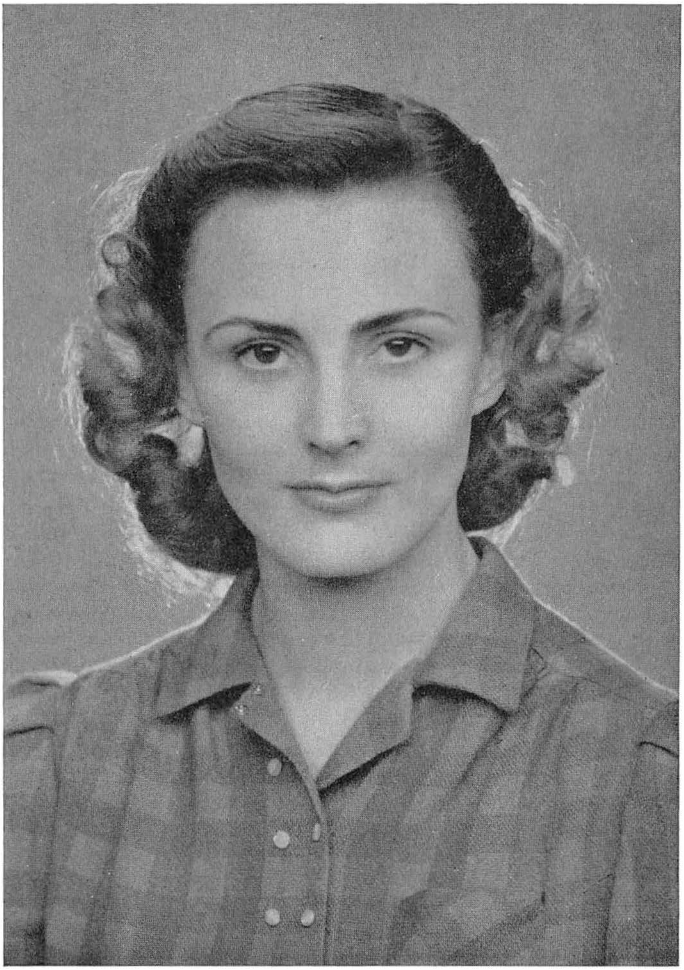
In cameras fitted with a side swing, the same method may be employed for getting both a near object on the right and a more distant part of the subject on the left in sharp focus without undue stopping down of the lens. Scenes in streets and market squares often lend themselves to this device, and even if the camera has not a side swing of the pattern shown in Fig. 37 in Chapter II, the focus may be helped in this way provided the back can be set askew on the runners on which normally it is held "square" to the lens, that is, at right-angles to the lens axis.

Focussing

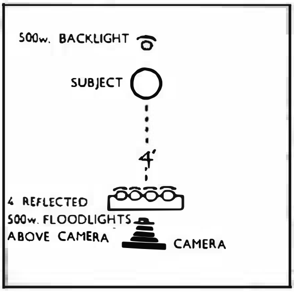
When any adjustments described in the preceding paragraphs have been made, the final focussing of the image is carried out,

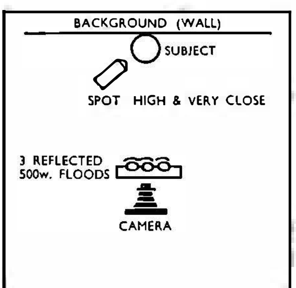
Usually, with a stand-camera it is desired to obtain all parts of the subject in sharp focus, which as a rule can only be done by stopping down the lens. Nevertheless, the focussing adjustment should be operated with the lens at full aperture and turned so as to bring first the mid-distance and then the near foreground into sharp focus. The amount of movement required to pass from one to the other will give an idea of the point on which to focus before sharpening the definition of the whole subject by the use of a smaller stop. In doing this it must always be remembered that the region of sharp focus, when an object in the mid-distance is focussed, extends much further behind this point than towards the camera. Hence, as a rule, it is well to focus on a point somewhat nearer and to note whether foreground and extreme distance become sharp as the lens aperture is reduced. Special care should be taken to note the definition at all parts of the screen whenever the swing back or rising front has been used. In all focussing a magnifier is of great aid, and especially so when the image is dim from poor light or a small stop. One cause of unsharpness, which is often unsuspected, is too coarse a ground-glass screen. Another, of less common occurrence, is dewing of the lens when the camera is taken into a hot, moist atmosphere such as that of a greenhouse.

For the most critical focussing the ground glass should be marked with an X in hard lead pencil in one or two places, and microscope cover glasses cemented over the marks with Canada balsam. The focus is sharp when the image and the pencil marks do not move relatively to one another when the head is moved from one side to the other.



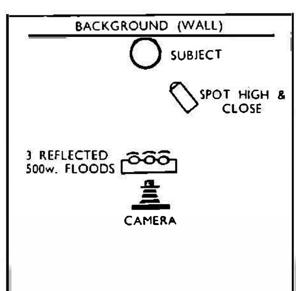
Harsh shadows and hard lines on cheeks and around mouth are avoided by this frontal lighting arrangement, but the result is too flat and lacks character. The back light placed in a low position lightens up the hair and relieves the flatness of the features.

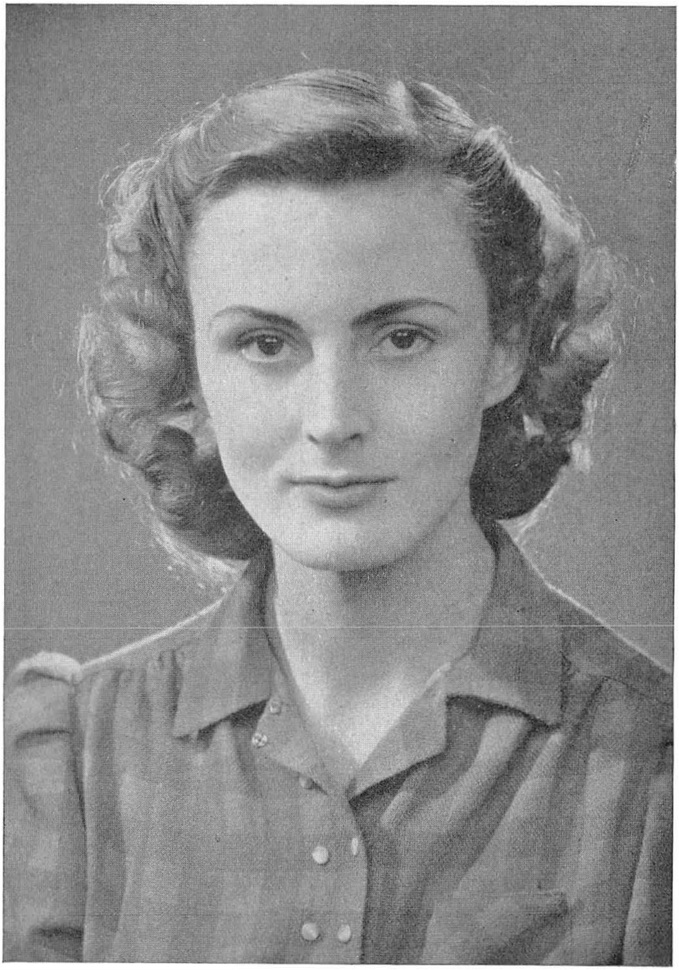


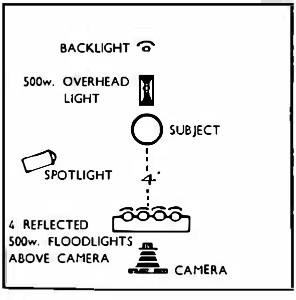


The addition of an undiffused spotlight introduces harsh shadows, giving a somewhat dramatic effect. This arrangement is suitable for character portraits of men.

Here the model has been moved closer to the background and the spotlight transferred to a more frontal position. The shadows have been lightened and modelling improved.

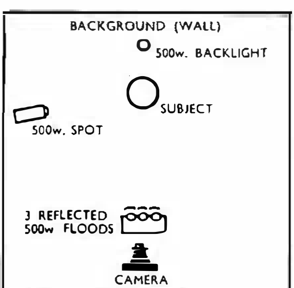


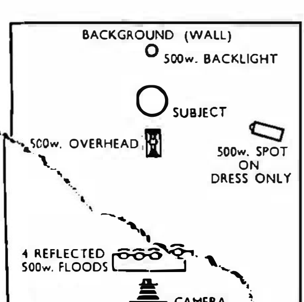




The most generally used form of studio lighting for this position, giving increased roundness to the features, with no harsh shadows or hard lines. The spotlight is diffused, and overhead and back lighting give lustre to the hair.

An ideal lighting arrangement for three-quarter length portraits. It will be seen that the back light has been directed on to the background to give depth to the picture.

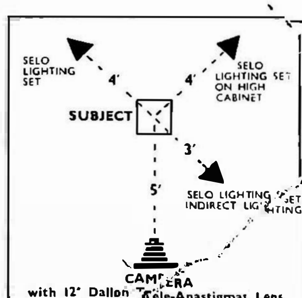


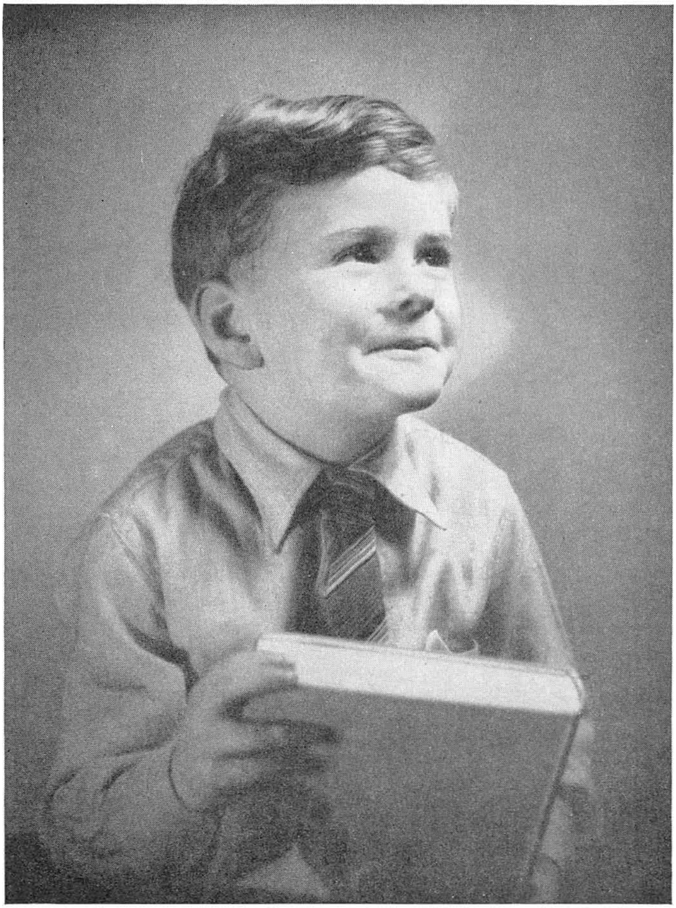


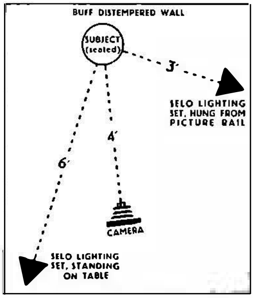
This is probably the most difficult portrait to take and it is necessary to ensure that the full length of the subject is evenly lighted and that modelling is preserved in the features. This arrangement is employed in a studio specializing in full-length fashion photographs.

Subject sitting back in armchair. Lighting on left side of face from Selo Lighting Set, placed on small table. Frontal lighting consisted of *indirect lighting* from Selo Lighting Set, the light being held slightly above level of the subject's head and pointing towards the floor. A third lighting set placed on a high cabinet provided back-lighting for top of head.

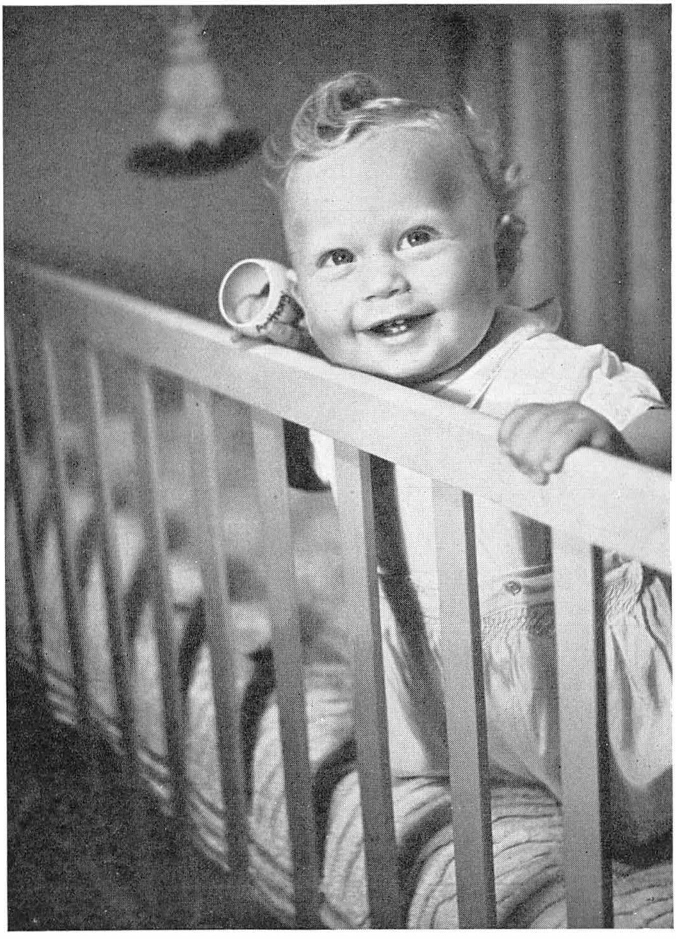
Exposure one twenty-fourth second at $f/5{\cdot}6$ on Ilford F.P.1 plate.



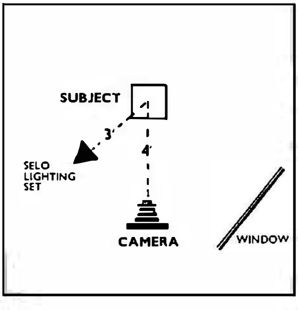


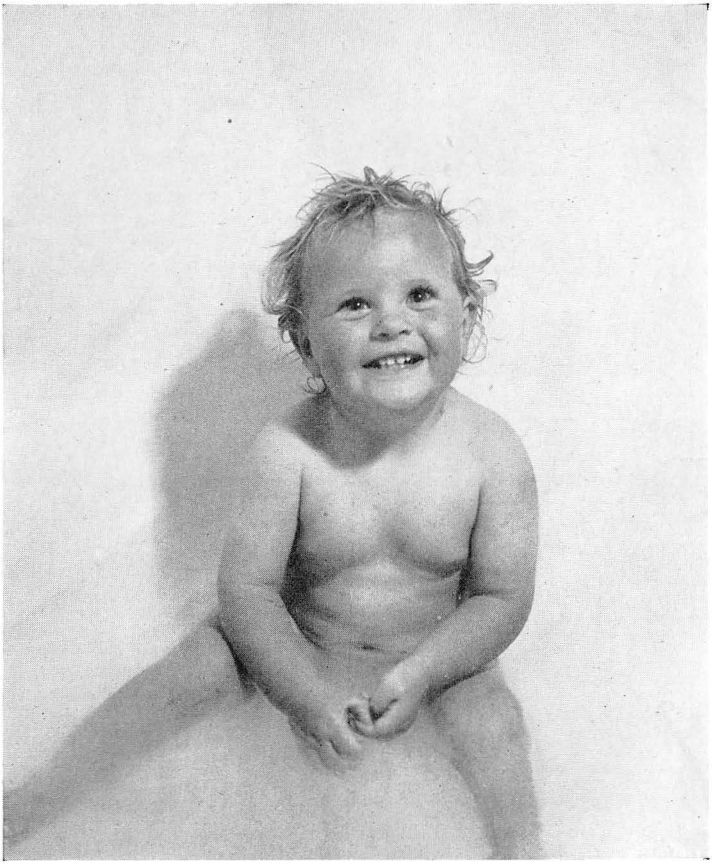


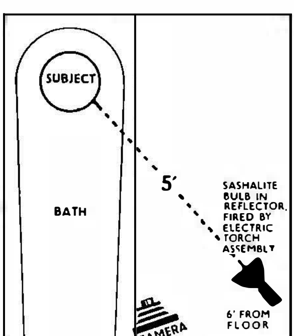
A "studio" type of portrait made at home with the aid of two Selo Lighting Sets. The sitter was slightly away from the buff distempered wall forming the background and the main lighting was from a Selo Lighting Set hanging from a picture rail at a distance of 3 feet. The exposure was one twenty-fifth second at *f*/3·8 on Selo H.P. Roll Film.



There are many advantages in photographing young children at home, the familiar environment having a reassuring effect on them, whilst their toys are readily at hand. For this picture, taken in the nursery, the exposure was one fiftieth second at *f*/3·8, the illumination being diffused daylight and one Selo Lighting Set 3 ft. from the subject. Negative on Selo H.P. Roll Film.

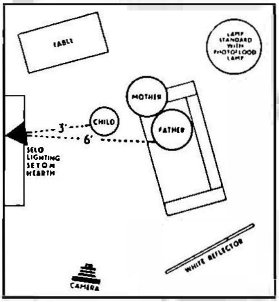


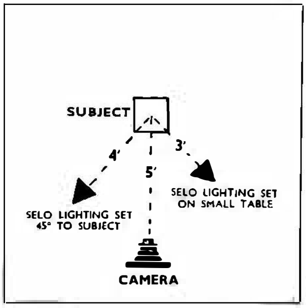




An aperture of *f*/16 and the light of one Baby Sashalite bulb in a silvered cone reflector held at a height of 6 feet, at a distance of 5 feet from the child, have given an excellent account of baby's bath-time. Negative on Selo H.P. Film.

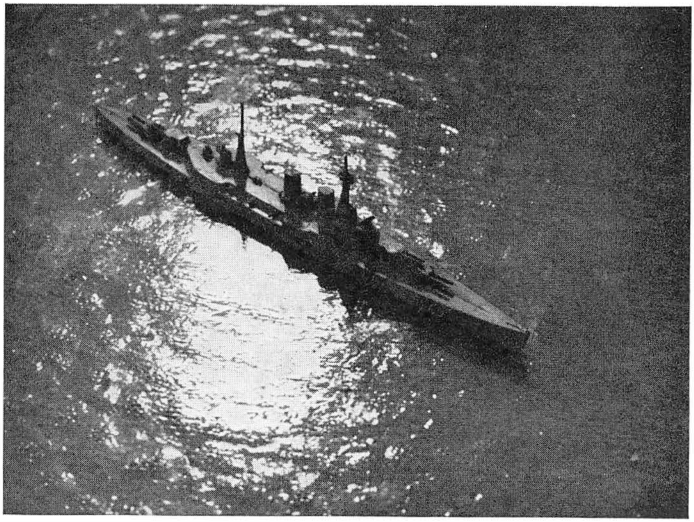
In addition to the lighting indicated in the diagram the ordinary ceiling lamp (100 watts) was alight. Exposure was one second at $f/4{\cdot}5$ on Selo H.P. Roll Film. The dark clothes and the considerable amount of shadow detail made a very full exposure necessary.



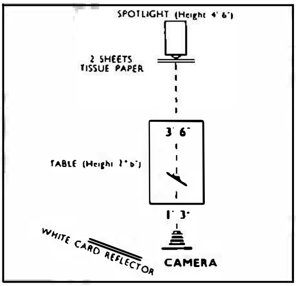


The tone of the background can be varied according to the distance at which the subject is placed from it. In this picture, taken in the centre of a room, the background appears medium to dark, yet the walls are light cream. Had the subject been nearer to the wall the lights would also have been nearer, so that sitter and wall would have been equally illuminated.

Exposure one fiftieth second at $f/3{\cdot}8$. Selo H.P. Roll Film.

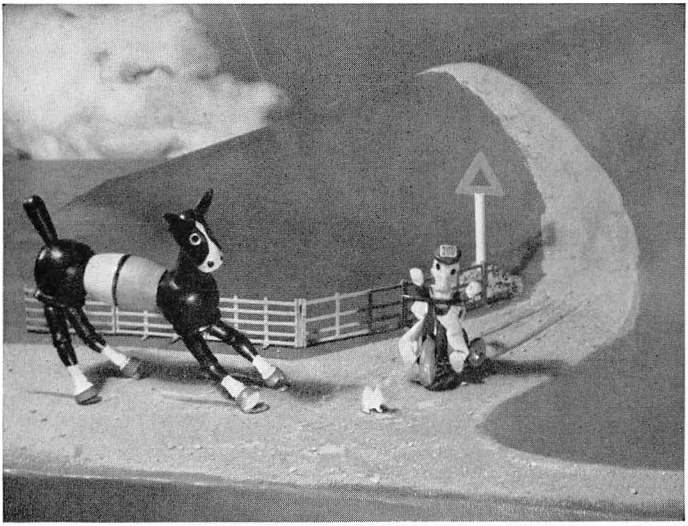


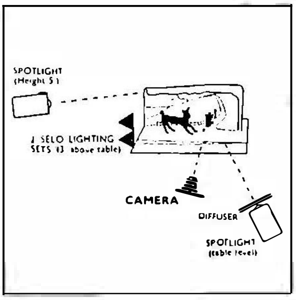
H.M.S. ————. A Meccano Dinky Toy.



The model was placed on a sheet of Muranese glass under which was laid a sheet of plain brown paper. The lighting came from one diffused spotlight placed at the back of the set and so arranged for height that an early morning sun effect on the water was secured. A white card was placed slightly to the left of the camera and was arranged at an angle to obtain shadow detail by reflection. There was no need to light the shadow side because very little detail was required, and this was obtained by the use of the reflector.

Exposure 20 seconds at *f*/32 on a Selochrome Plate.



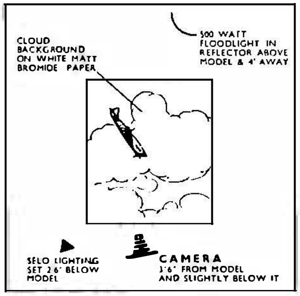


DONALD DUCK.

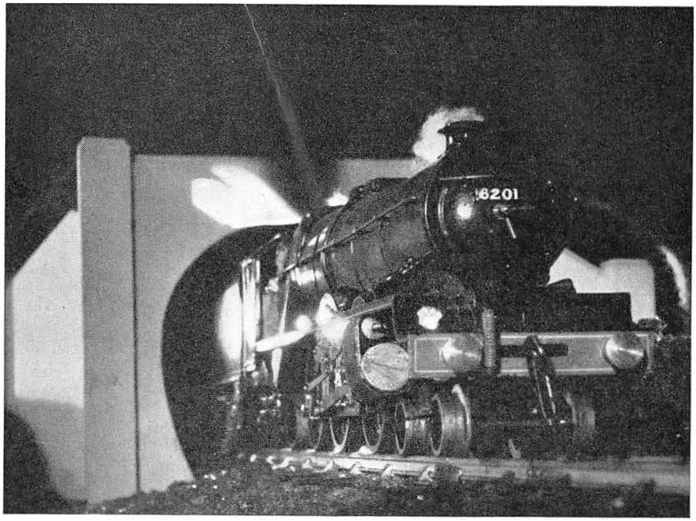
In order to obtain a sunlight effect the primary light was used at a height sufficient to correspond with the angle of the sun at midday. One of the two spotlights was placed at a distance where it helped to relieve the shadows and give roundness, while the other, arranged at an oblique angle, illuminated the "clouds" in the background and emphasized the relief.

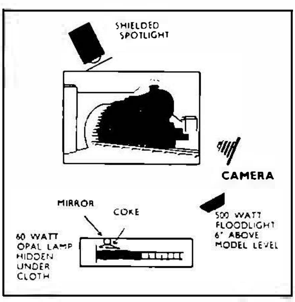
In the construction of the set, green wallpaper raised from the base into a hump and secured with drawing pins was employed for the hill, while sand sprinkled over an area previously gummed was used to make the road. The clouds in the background were made with cotton wool and placed well out of focus, and the toys borrowed for the occasion from baby's nursery.

Exposure 30 seconds at *f*/32 on Ilford H.P. Film.



SPITFIRE. Model by Woodason Aircraft Models. Heston.
The model was suspended on cotton before a background which was made by enlarging a cloud negative on to white matt Bromide paper. Such a background illuminated as evenly as possible reduces to a minimum the control necessary during enlarging from the negative. The primary light was so arranged above the model as to reveal its characteristic form to the best advantage, while the secondary light was placed below the model to prevent the lower portion of the sky from being underlit, and to relieve any dark shadows on the model which might otherwise be lacking in detail.
Exposure 18 seconds at $f/22$ on Ilford F.P. Plate.

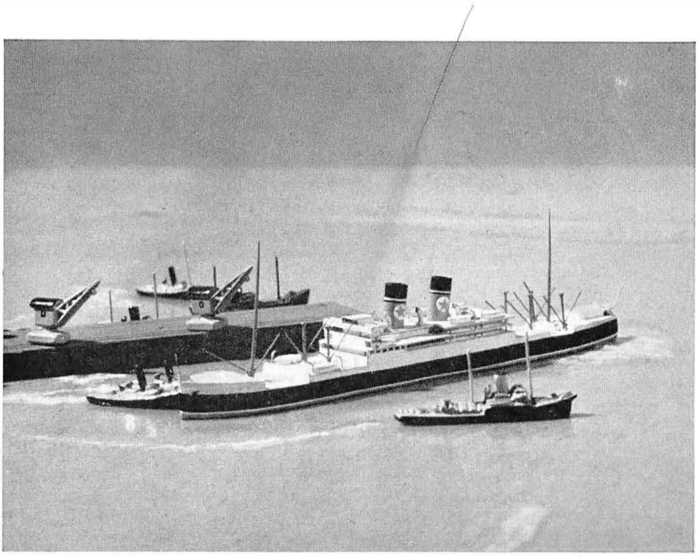


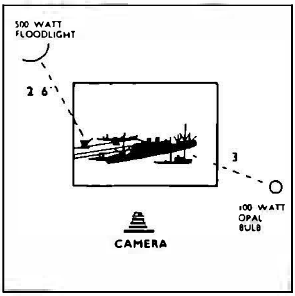


THE NIGHT EXPRESS. A Bassett-Lowke model of the L.M.S. Locomotive "Princess Elizabeth."

Success with subjects of this type depends to a large extent on careful control of the lighting and arrangement of reflecting surfaces to give highlight detail. The diagram shows the general lighting arrangement, but an additional 60-watt lamp was placed about 2 feet inside the tunnel to throw a highlight on the tender. The effect of the glare from the open firebox was secured by placing a small mirror on the far side of the engine, where it reflected the beam from the shielded spotlight on to the tunnel face. The track was held in position by a foundation of crushed coke and the smoke from the engine was made with cotton wool supported on a piece of thin wire and held in position by a pellet of Plasticine.

Exposure 8 minutes at *f*/64 on Ilford H.P. Film.



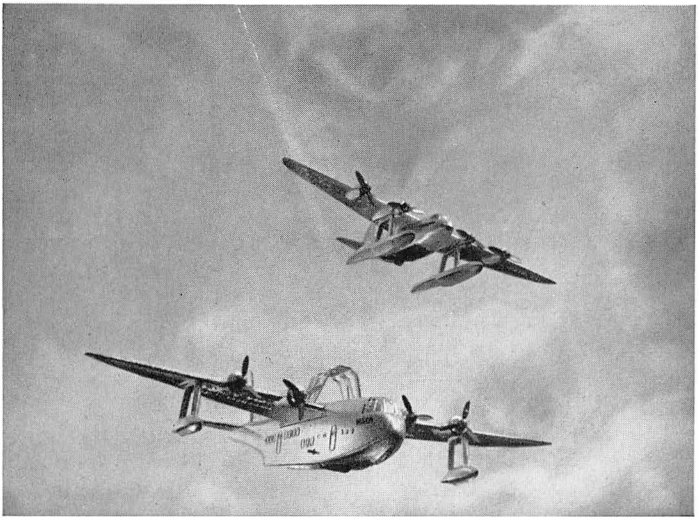


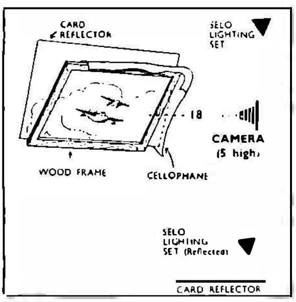
LEAVING PORT. Models by Bassett-Lowke and Mills Bros.

The sea was formed by placing a sheet of dry mounting tissue over a light grey card, and the wash at the liner's stern and from the other craft was made from soapsuds applied with a small paint brush.

A soft lighting arrangement was chosen to suggest a placid sea. This was achieved by the use of a large diffused floodlight (500 watts) placed behind and to the left of the set at a distance of 2 ft. 6 in., while the shadow side was relieved by means of a 100-watt opal lamp 3 ft. from the set and on the opposite side from the floodlight. In arranging lighting of this type, it is important to see that the secondary light is not too strong so as to compete with the main lighting which would throw additional shadows.

Exposure 40 seconds at *f*/45 on Ilford Fine Grain Panchromatic Film.





MAIA AND MERCURY IN FLIGHT.
Meccano Dinky Toys.

In this example, the clouds were made by pulling pieces of cotton wool into suitable shapes and attaching them to a sheet of Cellophane which was tightly stretched over a wooden frame. A large sheet of light grey card was placed behind this frame to serve as the "blue" sky and also to form a reflector from which the clouds were backlit by means of a Selo Lighting Set placed about two feet from the frame. The shadow side of the models was relieved by placing another Selo Lighting Set on the floor and five feet from the set. This second light did not point directly at the models but was turned at an angle towards a white reflector so that the illumination, which also served to light the clouds, was of a soft character. The most suitable relative positions of the lighting set and the reflector were determined by trial and error, and by reference to the ground glass screen of the camera.

The two models were suspended from the wooden frame on grey cotton thread.

Exposure 8 seconds at $f/32$ on an Ilford H.P. Plate.

CHAPTER VI

EXPOSURE

The effect produced upon the photographic plate by light is, roughly speaking, proportional to the product of intensity and time—if the intensity is halved the time of exposure must be doubled to get the same effect. This rule must be taken with reserve because it holds only within certain limits. Using exposure in the sense of the product of intensity and time, any given plate or film in a camera receives not one exposure over the entire surface, but an infinite number of different exposures according to the brightnesses of the various parts of the image cast by the lens. In each case the time of exposure is constant, but the intensity is different.

Let us see how these brightness differences arise.

THE LIGHT SOURCE

In the first place let us consider light from the sun falling upon an object out-of-doors. Of the light reaching the object a part will come direct from the sun, a part will consist of light which has been scattered by clouds and there may be a third part contributed by light which has been reflected from neighbouring objects. The total amount of light reaching any one point on the surface of the object is the sum of these three components and for different points on the surface the total amount of light received will vary as the sum of these three components varies. Should the intensity of light coming directly from the sun to the object be high compared with the other two components, then that aspect of the body which faces the sun will be very much more strongly lit than the other aspects and good modelling will result—the shape of the object will be easily apparent by reason of tone differences arising out of unequal illumination. If the direct component is small, the object will not so easily reveal its shape—all aspects will be fairly equally illuminated and it will have a flat appearance.

Before passing on to the nature of the object itself there is one further factor which must be considered.

Imagine that the sun is low down on the horizon and that it is shining through a small window in a room throwing a patch of bright sunlight on the opposite wall. This patch will be about the same size as the window if the line joining the window and the sun is nearly perpendicular to the walls. It would be possible to take a large piece of white card, place it against the wall and draw a line round the patch of light. If now one side of the cardboard were lifted away from the wall so that it made an appreciable angle with the wall (see Fig. 63) the patch of sunlight would be found to cover much more of the card than the area originally outlined.

The same amount of light passes through the window in each instance and it is inconceivable that this is influenced by the angle of the card. When the cardboard is tilted, the same amount of light is being spread over a larger surface and the amount of light per unit area is therefore smaller. This effect of the varying amount of light falling per unit area due to the obliquity of the sun's rays is partly responsible for the difference between summer and winter in this country. In summer in England the sun reaches high into the heavens at midday, but it rises relatively little above the horizon in winter. The amount of light and heat is, therefore, greater per unit area of earth in the summer than in the winter. Another cause of the difference in temperature between the English summer and winter is that the sun shines for a greater proportion of the day in summer than in winter. The sun is above the horizon in London for about $16\frac{1}{2}$ hours on June 21st and less than 8 hours on December 21st.

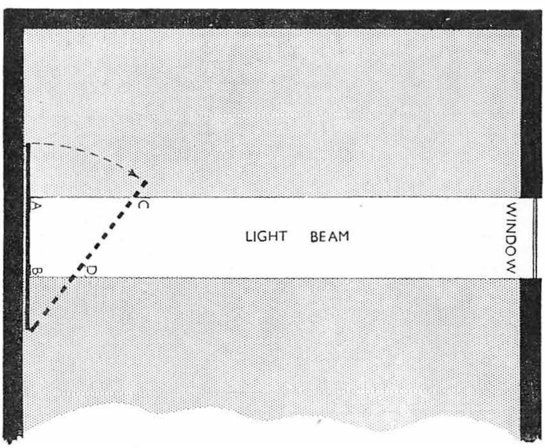


Fig. 63. Parallel light passing through the window falls on a piece of white card on the opposite wall. The width of the light patch is AB. When the card is tilted, the width of the patch measured on the card becomes CD which is obviously greater than AB. The same amount of light is therefore spread over a larger area.

The amount of light per unit area falling on the subject is of importance in estimating exposure, but the resulting brightness of the subject is the controlling factor. The nature of the surface of the various parts of the subject also influences the brightness. We shall next consider, therefore, the true meaning of brightness and the effect of the reflecting surface on subject brightness.

THE OBJECT PHOTOGRAPHED

The brightness of a surface depends not only on the intensity and direction of the light falling upon it, but upon its reflecting properties and upon the direction from which it is viewed or photographed. A surface which diffuses light fairly completely, such as a good blotting paper, looks equally bright no matter from which direction it is viewed, but a surface which reflects light in mirror fashion may look very bright or very dark, according to the angular relationship between source, surface, and eye.

We can now sum up the position by saying that different parts of the subject assume different brightnesses because of:—

(*a*) differing amounts of light reaching unit area of surface;
(*b*) differing directions of viewing or photographing;
(*c*) differing percentage reflections under the conditions of (*b*).

It is the function of the camera in conjunction with the sensitive plate or film to record these variations in brightness.

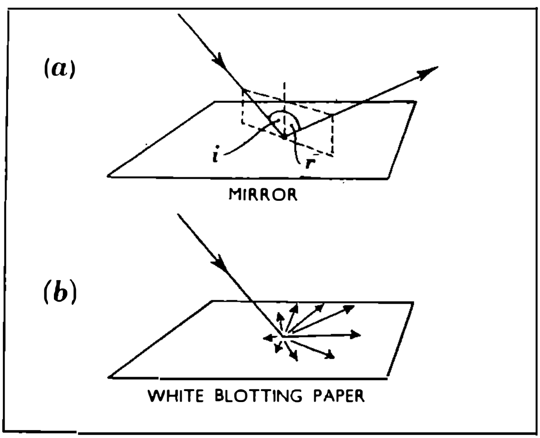


Fig. 64.

(*a*) Specular Reflection. Light incident in a direction making an angle i with the normal is reflected in the same plane as the incident light and the normal and makes an angle $r=i$ with the normal.

(*b*) Diffuse Reflection. Light incident in any direction is scattered in all possible directions.

THE LENS

We have already discussed image formation in Chapter I. Here we look at the matter from rather a different point of view. Consider a camera set up to photograph an object, for example, a tennis ball, illuminated by light from sun, sky and surrounding objects. Every point on the surface of the ball is scattering light in all directions. Let us consider a point on that part of the surface which faces the

camera. The amount of light which takes part in image formation within the camera is that part contained within the cone having the lens as base and the point itself as apex (see Fig. 65), *i.e.*, in the solid angle a/r^2 where a is the area of base and r the length of the sloping side.

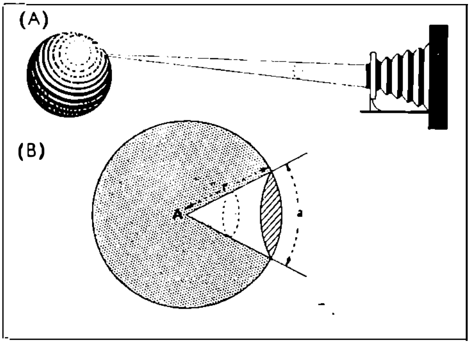


Fig. 65.

(*a*) A minute area of the ball is reflecting light in all possible directions, a small amount is collected by the camera lens. The light collected is in the form of a cone and the amount of light is measured by the magnitude of the solid angle.

(*b*) The magnitude of a solid angle is measured by describing an imaginary sphere round the apex A. The magnitude is then the area *a* of the surface of the sphere cut out by the cone divided by the square of the sphere's radius *r*.

The lens, therefore, collects an amount of light depending upon the brightness of the part of the subject under consideration and upon the solid angle subtended by the lens. If we double the distance of the lens from the subjcct we reducc the solid angle and the light collected to one-quarter. But at the same time we also reduce the area of the image to one-quarter and so its brightness remains constant. It is easy to see how this happens:—

$$\frac{\text{Size of image}}{\text{Size of object}} = \frac{\text{lens-image distance}}{\text{lens-object distance}} = \frac{u}{v}$$

$$\frac{\text{Area of image}}{\text{Area of object}} = \frac{u^2}{v^2}$$

The area of the object is constant and over a wide range of object distances the lens-plate distance u can also be taken as constant. It follows that the area of image is proportional to $1/v^2$. In other words if the object distance is doubled the image area is reduced to one-quarter. In ordinary photographic work, therefore, the exposure required is independent of the object distance.

In very close work, such as copying, variations in the lens-plate distance become significant; this distance can no longer be regarded as constant, and image brightness and exposure become dependent on magnification.

If we reduce the solid angle subtended by the lens by stopping down, *i.e.*, by reducing the effective area of the lens, then the image remains constant in size but its brightness falls off. Image brightness is proportional to the effective area of the lens and therefore inversely proportional to the square of the *f*/No.

To secure a successful negative the time for which the shutter is open must be such that the resulting range of exposures (brightness × time) must lie within the useful working range of the plate or film. The range of exposures may stretch along the foot of the characteristic curve and part way up the straight line portion or it may be arranged entirely on the straight line portion, or if the exposure has been unduly long it may start on the straight line portion and reach along the shoulder.

Units

Before we leave this general survey of the problem it may be helpful to set down the various units used in the measurement of amounts of light.

The unit of intensity is the candle. The total light flux emitted by a uniform source of one candle intensity is 12·57 lumens, one lumen being the total amount of light from a uniform point source of one candle intensity falling upon a surface of one square foot, every point of which is at a distance of one foot from the source. Illumination is defined in terms of lumens falling per unit area—one lumen per square metre is termed one metre candle (or lux) and one lumen per square foot is one foot candle.

It will be seen from this that were it possible to compute the illumination reaching each part of the image in terms of lux seconds there would be no difficulty in arriving at the correct exposure. In general, however, this is not possible and so we go to work another way.

EXPOSURE IN PRACTICE

The older school of photographers liked to rely entirely on experience and commonly prided themselves on their ability to determine exposures sufficiently accurately without any assistance from tables or measuring devices. Nowadays photographers in general like to get as much assistance as possible and there are many different exposure determining devices available, each of which can give useful assistance provided that it is used with care and judgment and with reference to the instructions issued with it. No meter yet made eliminates the need for personal judgment entirely, and to get the best out of any meter it is necessary to understand

what the instrument is doing and how to make allowances for factors with which it may not be able to deal.

We already know the factors which must be taken into account in the determination of exposure. Here we shall consider how to set about their evaluation.

The two factors always under control of the photographer are shutter speed and lens aperture. Of these, shutter speed depends in general on whether the subject is at rest or in motion. If it is in motion, shutter speed will have to be short enough to prevent the motion showing. Aperture will then have to be so adjusted that the right amount of light will reach the sensitive surface during the time the shutter is open. If the subject is at rest and there is a possible range of exposure time then a time should be chosen which will require an aperture giving the desired depth of field.

PLATE OR FILM SPEED

We have seen that the various exposures received by the different parts of the plate must be more or less correctly placed on the characteristic curve. It will be clear that we could do this by evaluating all the individual exposures in terms of candle-metre-seconds and by using a characteristic curve. Or we could do it more roughly by evaluating one or two of them, say the highest and the lowest, or we could do it even from only one of these, arranging the exposure so that the lowest would come at the bottom of the curve or the highest at the top. In practice, these individual exposures are rarely worked out in terms of candle-metre-seconds. In fact, it does not matter in what terms they are evaluated so long as the working speed of the film is known in similar terms. It is the function of the speed number to indicate the working range.

As already indicated in a previous section, although the speed number is not an easy thing to determine from a strictly scientific point of view, in practice working speeds can be allocated to materials sufficiently accurately for the purpose of estimating exposure, and although there is no true relationship between the various systems of speed numbers, practical correlations are given to assist the photographer, their best justification being that they are found to work. The simplest method of classifying materials is to divide them into groups in which the average speed in any one group is twice that of the previous group and half that of the next. Every practical photographer knows that when it is necessary to make sure of an exposure the best practice is to give a range of exposures increasing throughout the series by a factor of 2. It is on this experience that the Ilford Group System is based.

In general, the brightness range of the subject will be well within the range of the emulsion. It may be possible to give a series of exposures each a multiple of the previous one and get satisfactory negatives from them all, but every negative after the first, *i.e.*, the

one in which the minimum exposure was given, will be denser than need be, printing time will be higher than necessary and in all probability the image will be a little more grainy than it need have been. This is the reason for the old injunction, "Expose for the shadows." If we so arrange things that the area of image corresponding with the deepest shadow is just sufficiently exposed to record properly upon the emulsion the rest of the picture can be left to take care of itself. The minimum exposure to get satisfactory rendering is thus the correct exposure, and it is the light coming from the shadows which is significant.

From the foregoing we see how important it is to consider the type of subject and why, lighting conditions being equal, a subject with heavy shadows should have many times the exposure of a subject which has a short tone range. This is taken into account in all exposure tables which rely on visual estimation or which depend on the use of an exposure meter to measure light falling upon the subject or to measure the light reflected from the subject as a whole. In all such cases adjustments are made for type of subject and subjects are classified as seascapes, open landscapes, groups, glades, etc.

The exposure for a normal subject being 1, the necessary exposure for other types of subject will be roughly as indicated below, lighting conditions being constant throughout:—

Sea and sky	1/16
Distant landscape (panoramas and beach scenes)	1/8
Open landscape (fields, river scenes)	1/4
Open landscape with foreground (minor objects in foreground)	1/2
Standard—buildings and groups	1
Heavy foreground (narrow streets, close-up portraits, groups under trees)	2
Under trees (woodland scenes)	6 to 8

Now we see why even if we can measure light intensity correctly the determination of exposure is not quite automatic. If we measure the light intensity falling upon the above subjects we shall get the same value throughout, and yet from the table we see that the necessary exposure for heavy foreground scenes is about 32 times that for sea and sky subjects. On the other hand we may try to measure the light reflected from these various subjects, and here, although we shall not get a constant value of light intensity throughout the series, the differences found will not be sufficient to indicate an exposure change of the order which we have seen to be necessary. If it were possible for us to measure the intensity of light coming from the shadows of each subject, then we would get a true indication of the relative exposures, but only a very special piece of apparatus would enable us to do this properly and the difficulty of making the

measurement has, up to the present, been too great for practical purposes.

We are now in a position to examine the various aids which have been and are available to the photographer to assist him in the calculation of exposures.

ACTINOMETERS

The actinometer, or printing-out paper exposure meter, dates back to the early days. For many years exposure meters of this type were very popular and in many hands they proved very successful. In operation a small piece of printing-out paper is employed and the time is taken for this paper to print out to reach the same density as an adjacent piece of permanently tinted paper provided for the purpose of comparison. Such a meter should be held so that the paper faces the source of light and is directed upwards at an angle of about 45° so that the maximum useful light falling on the subject reaches the paper. It is very necessary to allow for type of subject. Some of these meters are still in use but in recent times they have gone out of favour partly because the papers supplied are not colour sensitive and misleading results are sometimes obtained with panchromatic materials. The method is slow compared with others available and it cannot be used in artificial light.

EXTINCTION METERS

A large number of different meters have been designed to assist the eye in making a definite measurement of light intensities. For example, the ability of the eye to distinguish a bright letter on a dark ground depends upon the actual intensity of the light with which the bright letter is illuminated, and it is on this principle that visual extinction meters work. The difficulty here is the variability of the reaction of the human eye according to external conditions. For instance, when out of doors in bright light, the eyes adjust themselves automatically to these conditions and become insensitive to low intensities. Indoors in poor light they again adjust themselves and become very sensitive. Thus, there is a tendency to underestimate intensity in bright light and over-estimate in poor light. It is possible to compensate for this, however, and there are many varieties of extinction meters for use indoors, outdoors, and in artificial light. They are amongst the most sensitive of exposure meters and can be used under conditions of very low illumination.

The visual meter can be directed either towards the subject or the light source. In the latter case it is obviously necessary to correct for type of subject. The most common method, however, is to point the meter towards the subject. Now if it is possible to direct the meter at each part of the subject in turn one may be able to

measure the intensity of light reflected from the shadows, and as already stated this will allow the subject to be correctly placed upon the characteristic curve of the negative material without more ado. If this cannot be done, however, as when the subject is some distance away, so that only a general idea can be obtained of the light reflected from it, then again a correction should be made for the subject by making allowance for the shadows.

PHOTO-ELECTRIC EXPOSURE METERS

The most popular exposure meters to-day are of the photo-electric type. These meters contain special photo-electric cells which are self-generating, *i.e.*, no battery is required and the current produced is of the order of several milliamperes in sunlight. In conjunction with the cell there must be a device to limit the angle of vision of the cell (acceptance angle) and a meter to indicate the value of the current produced. Then there must be a calibration table from which the necessary exposures may be derived in terms of aperture and time.

Photo-electric meters may be used in three ways:—

(1) The acceptance angle may be made so small that the light from small areas of the subject may be separately measured. Such a meter would enable one to place the subject on the characteristic curve with considerable precision. In practice, as we have seen, meters of this type are not commonly used.

(2) The acceptance angle may be such that the cell sees much the same picture as the camera lens. Such a cell will obtain a general reading for the light reflected from the subject. This is the method commonly adopted.

(3) The cell may be covered with a diffusing medium and in use directed towards the source of light to obtain a measure of the light falling upon the subject. This is the principle of the Smethurst Highlight Meter.

As we have seen, meters of the first type are not in common use. They involve small cell surfaces and the use of an amplifier and so are heavy. Meters working on the second method are common and give very good service indeed. Their success is due partly to the statistical relationship between the total amount of light reflected from a subject and the amounts reflected from its deepest shadow and brightest highlight and partly to the fact that the working range of negative materials to-day is much greater than the subject ranges with which the photographer is concerned.

Consider an average subject of brightness range 10 to 1. By means of a meter reading the total light reflected from the subject and a suitable calibration, we can place this range anywhere on the working range of the negative (see Fig. 66).

Imagine that the meter calibration is such that it places this subject in the middle of the working range of the material. It can easily be seen that in this case there is plenty of margin and that the total amount of light coming from the subject could vary quite widely without causing the photographer to obtain unprintable negatives.

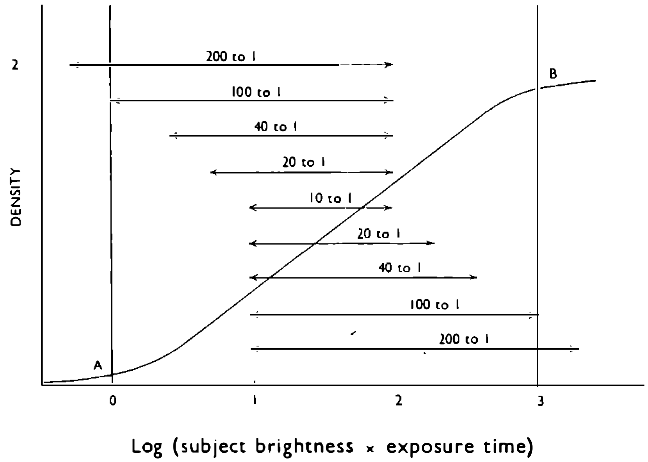


Fig. 66.

Now imagine that the total amount of light reflected from the subject remains constant, but that the shadows are deepened, *i.e.*, subject range is increased. The exposure indicated by the meter remains the same and again the subject is satisfactorily recorded, the shadows stretching downwards towards *A* (see Fig. 66) until the subject range becomes so long that it stretches beyond *A*. Again, if the subject range is extended by increasing the brightness of the highlights, the total amount of light remaining constant as before, the subject is correctly recorded until exposure range becomes so great that it passes beyond *B*. In both cases, of course, the extreme exposure range could be accommodated if the meter calibration were altered and the ranges shifted up and down respectively. In other words, we are saying once again that the long range subject must be given special consideration and that it is necessary to correct for type of subject.

When the meter is measuring total reflected light the reading is scarcely affected by the brightness of the shadows at all, but by making adjustments for type of subject it works well in practice. Another weakness is that the highlight is often the sky and the reading will vary according to how much sky is included in the field of view.

The third or highlight method is based on the measurement of the brightness of a perfect diffuser placed in the position of the subject so that it receives the maximum possible light, and on this system it is possible to place the highlight at the top of the working range of the sensitive material (or, in fact, at any point between *A* and *B* according to the calibration).

Once again (for negative-positive work) the best use of the system involves the making of adjustments for type of subject. For reversal work, on the other hand, the highlight method is ideal and no correction for type of subject is involved.

CALCULATORS

Many forms of exposure tables and calculators have been devised in which the light intensity is estimated at its most likely value, bearing in mind the time of day, time of year, etc., and factors are given for state of sky and type of subject. Such tables are often remarkably successful, a well-known example being the Selo World-Wide Exposure Tables.

These tables are of a simple type in which tiresome multiplication and division sums have been eliminated. In the first five tables numbers are given to each of the factors affecting exposure. To use, simply select the appropriate number from each of these tables, add them together and note the exposure time in seconds which corresponds with the total in Table VI.

TABLE I

PLATE AND FILM NUMBERS

Plates

H.P.3	− 3	Selochrome	+ 2
F.P.3	− 2	Golden Iso-Zenith	+ 2
Hypersensitive Panchromatic	− 1	Special Rapid Panchromatic	+ 4
Press Ortho Series II	− 1	Zenith 700	+ 4
Soft Gradation Panchromatic	+ 2	Auto-Filter	+ 6

Flat Films

Hypersensitive Panchromatic H.P.3	− 3
Portrait Panchromatic	+ 2
Hyperchromatic	+ 2
Portrait Ortho Fast	+ 4
Commercial Ortho	+ 8

Roll Films

Selo H.P.3	− 3
Selochrome	+ 2
Selo F.P. (Fine Grain Panchromatic)	+ 3
Selo Ortho	+ 4

Miniature Films

Selo H.P.3 (35 mm.)	− 3
Selo F.P.2 (Extra Fine Grain Panchromatic) (35 mm.)	+ 3

TABLE II

TIME OF DAY AND MONTH NUMBERS

Hour (G.M.T.)		June	May July	April August	March Sept.	Feb. Oct.	Jan. Nov.	Dec.
Noon		0	0	1	2	3	5	6
a.m. 11	p.m. 1	0	0	1	2	4	6	7
10	2	0	0	1	2	5	7	8
9	3	0	1	2	3	6	11	12
8	4	1	2	3	5	10	—	—
7	5	3	4	5	8	—	—	—
6	6	4	5	8	—	—	—	—

This table (for latitude about 53°N.) is suitable for exposures in the British Isles, Holland, Belgium, Denmark, North Germany, and Mid-Russia.

TABLE III

BRIGHTNESS NUMBERS

Sunshine, white clouds . .	0	Dull . .	8
Sunshine, blue sky . . .	2	Very dull .	12
Slightly overcast sky . .	5		

TABLE IV

SCENE NUMBERS

Sea, sky, and extreme distance: no foreground . . .	Subtract	5
Distant landscape. Beach scenes	Add	0
Open landscape with foreground	,,	3
Distant buildings. Wide streets	,,	5
Near view of houses, trees, etc., distant figures or groups .	,,	6
Landscapes with heavy foreground	,,	8
Close-up portraits or groups in the open air . . .	,,	10

TABLE V

APERTURE NUMBERS

f/4·5	*f*/5·6	*f*/8	*f*/11	*f*/16
0	2	5	8	11

Where it is required to use stop *f*/3·5 the exposure suitable will be half that of *f*/4·5 as indicated by the table.

TABLE VI

EXPOSURE REQUIRED

Total 1–5	Exp. Secs.	Total 1–5	Exp. Secs.	Total 1–5	Exp. Secs.
5	1/1000	18	1/50	32	1/2
8	1/500	21	1/25	35	1
11	1/250	25	1/10	38	2
15	1/100	28	1/5	42	5

In these tables the factors which we have already discussed are classified and numbers are allotted in each group to the conditions prevailing at the time of making the exposure. These various numbers are then totalled and from the result the exposure is derived directly.

The various classifications are:—

(1) Speed of sensitive material.
(2) Time of day for a given latitude.
(3) Weather conditions.
(4) Type of subject.
(5) Lens apertures.

(1) We have already dealt with the speed of sensitive material in so far as it applies to the determination of exposure.

(2) **Time of Day.** As we have seen, the strength or intensity of unobstructed sunlight varies with the height of the sun above the horizon and thus alters from hour to hour on any day of the year, being less and varying more rapidly during the winter months. The numbers given take account of the variations, and separate tables are available for different latitudes.

(3) Next to the power of the sun's light as determined by the latitudc and time of day and year, the state of the sky has an important bearing on the amount of light getting to the subject and so numbers must be allotted for this also. Floating sunlit clouds give rise to an illumination which lights up the shadows. A light of this kind, which may be called "Sunshine, White Clouds," is almost twice as active as far as exposure is concerned as one from blue sky only, owing to the scatter of light into the shadows. A very slight haze—not enough to prevent the sun casting sharp shadows and through which blue sky can be seen—has about the same effect. It is the absence of this scattered light on cloudless days of sunshine that often misleads the beginner into under-exposure. This applies especially to countries where the light is dazzlingly bright but comes from a cloudless sky; India in the dry season, Egypt, and South Africa. The rule should be to observe

the shadows in the subject and bear in mind that they require a good deal of exposure—it is often surprising how much they will stand—for rendering of detail.

Next in order of illumination comes the "Cloudy Sky," *viz.*, one covered all over with *light* clouds, just about enough to hide the sun and prevent the formation of definite shadows—a pleasant, cheerful state of weather such as often prevails in England in early summer.

A sky covered with clouds which are distinctly low in tone may be called "dull," after which comes one in which the clouds are heavy and lowering, otherwise "very dull"—the kind of weather in which one would hardly think it worth while to use a camera, so gloomy is it.

The next table (IV) deals with type of subject, which we have already considered in some detail on an earlier page, and the following one (V) is concerned with lens apertures.

Example

It is desired to take a picture of some distant buildings. The camera contains Selo H.P.3 35 mm. Film and it is 11.30 a.m. on a March morning in London, with sunshine and white clouds in the sky. The aperture which it is proposed to use will be $f/4{\cdot}5$. The calculation proceeds as follows:—

From	Table I ..	Selo H.P.3	—3
,,	Table II ..	11.30 a.m. March	2
,,	Table III ..	Sunshine, white clouds ..	0
,,	Table IV ..	Distant buildings	5
,,	Table V ..	$f/4{\cdot}5$	0
		Total	4

Exposure from Table VI = 1/1000 second.

ARTIFICIAL LIGHT WORK

With artificial light, as with daylight, any range of exposures could be correctly placed on the characteristic curve if it were possible to evaluate the brightness of each part of the subject, and, similarly, a very good approximation to the correct exposure can be obtained by way of a speed number used in conjunction with a suitable calibration table. There is one advantage in artificial light work—illumination can be estimated fairly accurately in terms of lamp output, direction and distance. The colour of the light and the colour sensitivity of the material must, however, be reckoned with. Very many tables have been worked out for specific purposes and for different types of lighting. We give on pages 159-160 a set of tables for use with Ilford and Selo plates and films, but first we must describe a still simpler exposure indicator for indoor subjects photographed at night on hypersensitive panchromatic material and illuminated by one photoflood lamp in reflector.

EXPOSURE INDICATOR

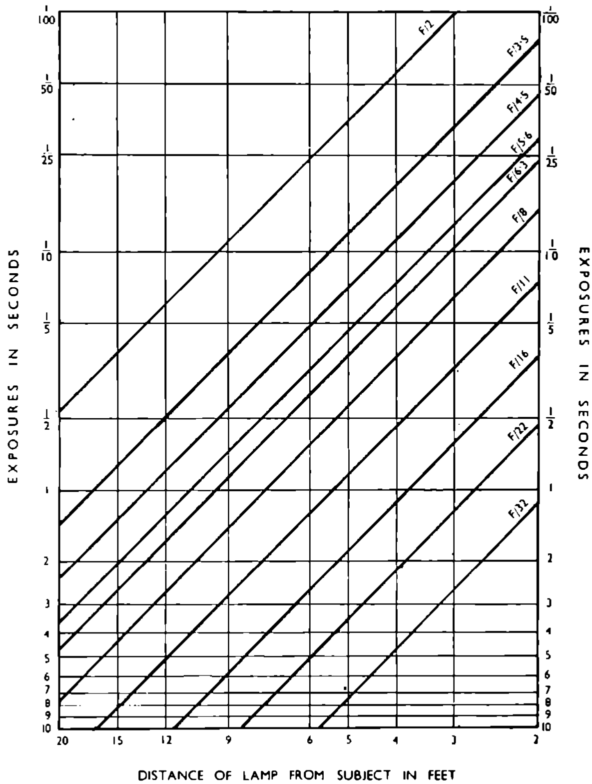


Fig. 67.

It is simplest to decide which is the *maximum* shutter exposure you can give to the subject. Apply this exposure to the upright scale and read along the horizontal line until it is intersected by the lens aperture reference line. Now read downwards perpendicularly and the scale at the foot will indicate the necessary distance of the lighting set from the subject. Alternatively, the procedure may be reversed by taking the distance of the lamp as the standard, reading the indicator vertically to the lens aperture reference line and then horizontally to the required shutter exposure.

When two lighting sets are being used they may be a *little* further from the subject than the indicated distance, or alternatively, rather more than half the exposure may be given if the two lamps are used at the stated distance.

It is possible to construct logarithmic tables for artificial light work similar in nature to those already given for daylight photography. Here, numbers are allotted for speed of emulsion, intensity and direction of light and for aperture chosen. Again it is convenient to take 3 units to indicate a difference (in every condition) the effect of which is to cause the necessary exposure time to be halved or doubled.

In the following tables only the lamps constituting the main light should be evaluated. If one lamp only has then to be taken into account the proceedings are straightforward. If more than one lamp has to be considered, sum up the total wattage and consider the light as all coming from one source at an intermediate distance.

It is assumed that the lamps are used in reflectors.

TABLE I

EMULSION SPEED

Selo H.P.3 35 mm. Miniature Camera Film	− 3
Ilford H.P.3 Plate	− 3
Selo H.P.3 Roll Film	− 3
Ilford F.P.3 Plate	− 2
Ilford Hypersensitive Panchromatic Plate .	− 1
Ilford Soft Gradation Panchromatic Plate	+ 2
Selo Fine Grain Panchromatic Roll Film .	+ 3
Selo F.P.2 Extra Fine Grain Panchromatic 35 mm. Miniature Camera Film . .	+ 3
Ilford Special Rapid Panchromatic Plate .	+ 4

TABLE II

LIGHT INTENSITY

3200 watts	2
1600 ,, ...	5
800 ,, ...	8
400 ,, ...	11
200 ,, ...	14
100 ,, ...	17

Note.—Effective wattage of one photoflood = 750. Approximate value in Table II = 8.

TABLE III

DISTANCE AND DIRECTION

Distance	45°	55°	65°
4 ft.	1	4	7
6 ,, ...	5	8	11
8 ,, ...	7	10	13
12 ,, ...	11	14	17

TABLE IV

APERTURES

$f/2$	0
$f/3{\cdot}5$	3
$f/4{\cdot}5$	6
$f/6{\cdot}3$	9

TABLE V

EXPOSURE TABLE

Total	Exposure
2	1/500
5	1/250
8	1/100
11	1/50
14	1/25
17	1/10
20	1/5
23	1/2

Example

To find the exposure using Selo H.P.3 35 mm. Film at $f/4{\cdot}5$, the lighting being 800 watts, 6 ft. from subject, directed at 45°.

From Table I	H.P.3 35 mm. Film	−3
,, Table II	800 watts	8
,, Table III	6 ft. 45°	5
,, Table IV	$f/4{\cdot}5$	6
	Total	16

Exposure from Table V = 1/10 second.

EXPOSURE TABLE FOR COPYING

Here again logarithmic tables have been worked out. Numbers are allotted as before to the factors operating and all that is necessary is to sum the numbers to arrive at the recommended exposure.

TABLE I

EMULSION SPEEDS

Ilford Process Panchromatic Plate	0
Ilford Special Rapid Plate	1
Ilford Ordinary Plate	7
Ilford Fine Grain Ordinary Film	7
Ilford Process Plate or Film	12
Ilford Diapositive Film	12

TABLE II

DISTANCE OF LAMPS IN FEET FROM COPY

1 ft.	−3
2 ,,	+3
3 ,,	+7
4 ,,	9

Note.—It is assumed that lamps are used in efficient reflectors.

TABLE III

WATTAGE OF LAMP

It is assumed that the lamps are being used in reflectors.

To obtain the correct factor from this table sum the wattage of all the lamps used.

4000 watts	− 6
2000 ,,	− 3
1000 ,,	0
500 ,,	3
250 ,,	6
100 ,,	9
50 ,,	12
25 ,,	15

Note.—Effective wattage of one photoflood = 750. Approximate value in Table III = 1.

TABLE IV

APERTURE CHOSEN

f/5·6	0
f/6·3	2
f/8	3
f/11	6
f/16	9
f/22	12
f/32	15

TABLE V

CORRECTION FOR SCALE OF REPRODUCTION

Image size — Object size	
$\frac{1}{4}$ or less	0
$\frac{1}{2}$	3
1	6

TABLE VI

CORRECTION FOR TYPE OF SUBJECT

Black line drawings on white paper	0
Matt or semi-matt bromide prints; Pencil or ink sketches	6
Contrasty glossy bromide prints; Black photogravure prints	9

TABLE VII

EXPOSURES

Total	Exposure Time
18	$\frac{1}{4}$ sec.
21	$\frac{1}{2}$,,
24	1 ,,
27	2 ,,
30	4 ,,
33	8 ,,
36	16 ,,
39	32 ,,
42	64 ,,

Example I

The camera is loaded with Diapositive Film and two 500-watt lamps are used 2 ft. from subject. Aperture chosen is $f/16$.

Subject: Black drawing on white paper.

Diagonal of document ..	22 cm.
Diagonal of image ..	4·3 cm.
Scale of reproduction	$\frac{4{\cdot}3}{22} = \frac{1}{5}$

From Table I	..	Diapositive Film	12
,, Table II	..	2 ft.	3
,, Table III	..	1000 watts	0
,, Table IV	..	$f/16$	9
,, Table V	..	One-fifth	0
,, Table VI	..	Black drawing on white paper	0
		Total	24

From Table VII Exposure = 1 second.

Example II

The camera is loaded with Process Plates and 2 × 1500-watt lamps are used 3 ft. from the copy. Aperture chosen is $f/16$. Same size reproduction.

Subject: Water-colour drawing.

From Table I	..	Process Plate ..	12
,, Table II	..	3 ft.	7
,, Table III	..	3000 watts	—4
,, Table IV	..	$f/16$	9
,, Table V	..	Same size	6
,, Table VI	..	,, ...	6
		Total ..	36

Exposure = 16 seconds.

Example III

The camera is loaded with Diapositive Film and 2 × 500-watt lamps are used 2 ft. from the copy. Aperture chosen *f*/16. Reduction to one-eighth.

Subject: Typescript.

From Table I ..	12
,, Table II ..	3
,, Table III ..	0
,, Table IV ..	9
,, Table V ..	0
,, Table VI ..	0
Total	24

Exposure = 1 second.

For further guidance we now append some useful miscellaneous information about the exposures required with Ilford materials under certain specified conditions.

INTERIOR DAYLIGHT WITH SELOCHROME

Light Conditions.	Recommended Exposure at *f*/16.					
	Dark Coloured Walls.		Medium Coloured Walls.		Light Coloured Walls.	
	One window.	More than one.	One window.	More than one.	One window.	More than one.
Intense sunlight .	35 sec.	20 sec.	15 sec.	10 sec.	7 sec.	4 sec.
Bright sunlight .	60 sec.	40 sec.	30 sec.	20 sec.	14 sec.	8 sec.
Cloudy–bright .	2½ min.	1½ min.	1 min.	40 sec.	28 sec.	16 sec.
Dull–cloudy .	5 min.	3 min.	2 min.	1½ min.	56 sec.	32 sec.
Very dull . .	9 min.	5 min.	4 min.	3 min.	2 min.	1 min.

This table has been worked out primarily for users of box cameras—hence the aperture quoted. It assumes that it is summer, that the sun is high in the sky and that the light enters the room freely. For portraiture within 6 ft. of the window give one-quarter of the exposure. With Hypersensitive Panchromatic film give one-half the exposure indicated for Selochrome.

Exposure by Mercury Vapour and Sodium Discharge Street Lamps

General night scenes using Hypersensitive Panchromatic Plate or Film.

Mercury vapour	1 to 2 seconds at *f*/4·5
Sodium discharge	3 to 4 seconds at *f*/4·5

Exposures with Ilford Hypersensitive Panchromatic Plates for Subjects Illuminated by Some Unusual Sources

Match close to subject	*f*/4·5, ½ second
Gaslamp approximately 2 ft. between lamp and subject	*f*/4·5, ¼ second
Paraffin lamp	As above
Headlamp of motor car, 30–40 watts approx. ..	*f*/4·5, $\frac{1}{10}$ second

Distance and Stop for Hypersensitive Panchromatic Film or Plate with One Large Sashalite Bulb

Distance	*Stop*
Up to 10 ft. ..	*f*/22
11 to 20 ft. ..	*f*/16
21 to 30 ft.	*f*/11
31 to 50 ft.	*f*/8

Distance and Stop for Hypersensitive Panchromatic Film or Plate with One Baby Sashalite Bulb

Distance	*Stop*
Up to 6 ft.	*f*/16
7 to 12 ft.	*f*/11
13 to 24 ft.	*f*/8
25 to 36 ft.	*f*/6·3

Set shutter at time or bulb. Cover the lens immediately after flash.

Flash Bulb Exposure Data. Exposure with Synchronized Shutter

Source .. .. One large Sashalite Bulb
Sensitive material . Hypersensitive Panchromatic Plate or Film

Distance in Feet.	Apertures and Shutter Speeds.				
	1/75 sec.	1/100 sec.	1/250 sec.	1/500 sec.	1/1000 sec.
Up to 10 ft. .	f/22	f/16	f/11	f/8	f/5·6
11 to 20 ,, .	f/16	f/11	f/8	f/5·6	f/4
21 to 30 ,, .	f/11	f/8	f/5·6	f/4	f/2·8
31 to 50 ,, .	f/8	f/5·6	f/4	f/2·8	f/2

The exposure data given should be used with discretion, bearing in mind the type of subject, the developer used, and the conditions of development. They will, however, form a useful basis upon which to experiment.

Flash Powder Exposures with Hypersensitive Panchromatic Plate or Film at an Aperture of *f*/8

Distance of Subject in Feet.	Size of Room in Feet:			Grains Required.
	Length.	Breadth.	Height.	
9 . . .	15	6	10	15
15 . . .	20	6	10	30
20 . . .	25	10	10	75
25 . . .	30	10	10	120
30 . . .	35	12	10	180

Magnesium Ribbon Exposures with Hypersensitive Panchromatic Plate or Film

Two 4-in. lengths of magnesium ribbon.
$\frac{1}{2}$ to 1 second at *f*/8.

CHAPTER VII

THE DARKROOM

Darkroom Illumination. Darkroom illumination must be considered in relation to the particular sensitive material or materials to be handled. With fast negative panchromatic plates and films no light at all should be used, development being strictly to time and temperature. Safelights such as the Ilford "G.B." No. 908 may be used for illumination of the darkroom clock, for example, but the direct light should not be allowed to fall upon the sensitive materials. For the slower and less colour-sensitive negative materials the aim should be to achieve the highest level of illumination consistent with safety, and this means careful choice and positioning of the safelight. By judicious arrangement and selection, the general illumination may be maintained at a surprisingly high value without danger of fogging, whereas a badly placed or inefficient safelight may give little useful light and yet quite belie its name. Generally, it is convenient to have additional safelights illuminating particular objects or corners, and sometimes, of course, as in the case of fast panchromatic materials, it is possible to illuminate one important object, such as the darkroom clock, when it is unsafe to have the room generally illuminated.

Modern darkroom illumination practice is to secure the maximum reflected light from walls and ceilings—in some cases all the general illumination is derived in this way. To this end, walls and ceilings are generally coloured white, lime green, light stone or primrose yellow, ivory or cream. Deep buffs, orange yellow, or grass green, should be avoided because of their low reflectance in those parts of the spectrum which are transmitted by the safelights (yellow, bright green, and red) which will be in use when a fairly high degree of general illumination is permissible.

Paints or enamel paints with a high gloss should be chosen, as they will reflect more light than the corresponding matt finishes. The paint should also be washable and proof against flaking or chipping. The ceiling is preferably painted glossy white, especially if a ceiling reflector lamp is used. Other normal requirements are that the paint should have good covering power, body, and opacity, and an undercoat of the recommended shade should be used. It is assumed that the surface to be painted will have been suitably prepared and primed.

Entrance to the smaller darkrooms is usually by double doors, in larger premises a maze may be used. The walls comprising the maze or between the doors should be painted to a dead matt black. Glossy tiles, linoleum, or terrazzo should be avoided.

The floor of the darkroom should be covered with linoleum or some washable material such as unpolished rubber. It need not be light in colour, although if it is so coloured the fact may prove an incentive to greater cleanliness.

To come now to actual light sources, considerable attention has been paid by manufacturers to the production of efficient safelights, and of these there is now a considerable range from which choice must be made according to the nature of the material being handled.

The absorption curves of Ilford safelights are illustrated below:

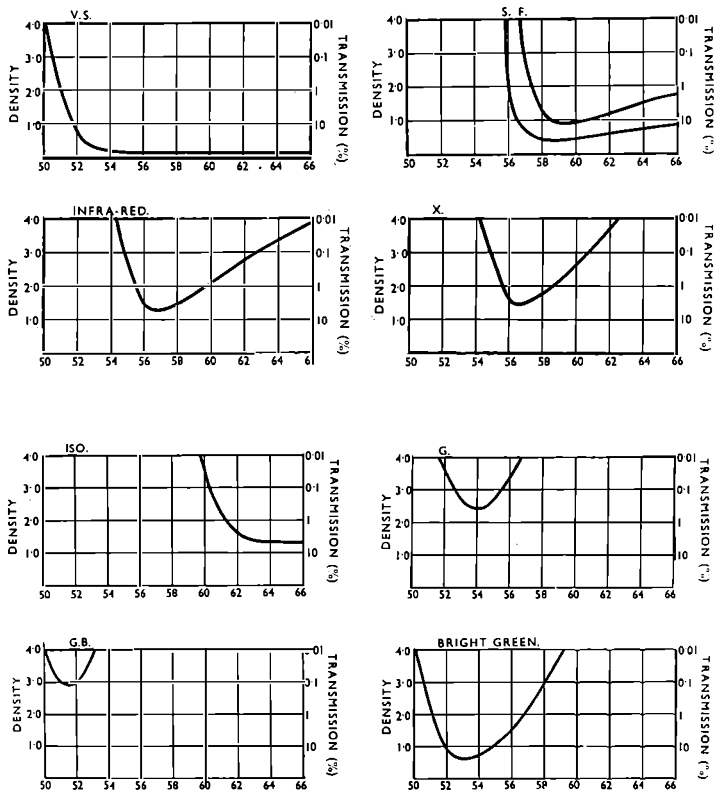


Fig. 68. Absorption Curves of Ilford Safelights.

Ilford Safelights may be classified as follows:—

Sensitive Material		*Safelight* Symbol	Number	*Safelight Colour*
Non-Colour Sensitive (Ordinary)	Slow	"S"	902	Light Brown
	Fast	"F"	904	Dark Brown
		"X"	905	Olive Green

Sensitive Material	*Safelight* Symbol	Number	*Safelight Colour*
Blue and Green Sensitive (Orthochromatic)	Iso	906	Ruby-Red
Blue and Green and Red Sensitive (Panchromatic)	"G.B."	908	Green-Blue
Infra-red Sensitive	"I-R"	903	Yellow-Green absorbs Infra-red completely.
Desensitized Panchromatic Materials	Bright Green	909	Green

Because of the fact that visual sensitivity is at a maximum in the yellow-green, with a shift towards the shorter wavelengths (blue end) for the dark adapted eye, *i.e.*, at low luminosities, a green or yellow-green safelight is particularly effective for producing general illumination. On the other hand, it is true that visual acuity, *i.e.*, the power to distinguish fine detail at low levels of illumination, is greater for red light than for green when visual brightnesses are the same, so that a red light is not to be despised, particularly when it is being used for the illumination of some specific object. These are, of course, but two factors in the situation to be considered in conjunction with the third and most important factor, namely, the sensitivity of the material in question. With fast panchromatic materials, no light is properly called "safe"—but the Ilford "G.B." Safelight transmits light of low intensity in the region where the sensitivity of the material is at a minimum and the visual sensitivity at a maximum.

The lamphouse in which the safelight is used is also of the greatest importance, and the design should be one which will ensure adequate ventilation, without which the safelight (which normally comprises one or more glasses coated with dyed gelatin) will deteriorate

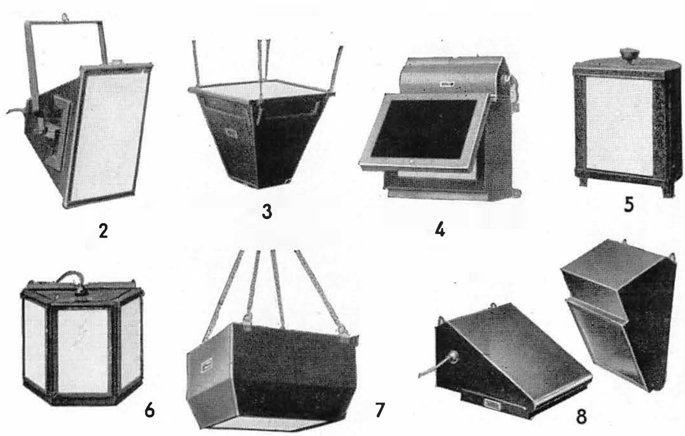


Fig. 69. Ilford Darkroom Lamps

quickly. All Ilford darkroom lamps are exceptionally well ventilated. In all, eight types are provided, Nos. 2a, 4, 5, 6, and 8 are designed to provide direct illumination, and Nos. 3 and 7 for indirect lighting. No. 2 can be used for either system. (Note: No. 2a is similar to No. 2, but without suspension arms.) In lamps No. 4 and No. 8 the safelight panel is itself indirectly lighted and illumination is quite even right to the edges. No. 5 is a rotating turret lamp; this form is very convenient where it is necessary to use various types of safelights. Any one of three safelights can be brought readily into use by simply rotating the lamp. Whatever the type of safelight illumination, reflected or direct, it is essential to test it out by exposing material of the type to be handled for a time at least equal to that for which it will be exposed in practice and at the same distance from the light. The exposed film or plate must be processed side by side with a second piece taken direct from the box and not exposed. If any trace of veil is visible on the test piece when both are held against white paper, the illumination is unsafe and must be reduced. Either the power of the lamp must be cut down or the distance increased.

The operations performed in the darkroom include loading and unloading of plates, processing of exposed plates and films, and the making of prints either by contact or enlargement on Bromide and Chlorobromide papers. (Gaslight printing can be done in an ordinary room.) This means that there must be bench or table space upon which one can handle sensitive materials without fear of water, solutions, or dry chemicals coming into contact with them. There must also be space for processing dishes, or tanks for washing negatives and prints.

The amateur is, of course, often obliged to make temporary use of a room designed and normally used for other purposes, and generally chooses the bathroom because running water is nearly essential. A method of converting the bath is shown on page 170, and the following details will amplify those given in Fig. 70.

Having made the window light-tight by means of a well-fitting blind running in grooves, or at least behind slats, set up the framework, which consists of a piece of plywood 6 × 3 ft. backed by a frame made of 2 × 1 in. deal with a bearer running across the centre, over the bath, to take the dishes and processing solutions. On referring to Fig. 70 it will be seen that the bench is divided into two parts by a movable partition, the right half being used for developing, fixing and washing, and the other half for exposing. The half used for developing, etc., should be covered with American cloth carried over the binding round the edge to prevent spilt solutions running on to the bath and staining it.

For print washing, a rubber hose can be connected to the bath cold water tap and a syphon fixed up to the bath waste.

A darkroom lamp, an Ilford Darkroom Lamp No. 3 is very suitable, can be set into the partition and arranged so that it illuminates both sides equally, and a development timer can be inserted into a semi-circular hole cut in the bottom back of the partition, where it can be read from either side for timing exposures and development.

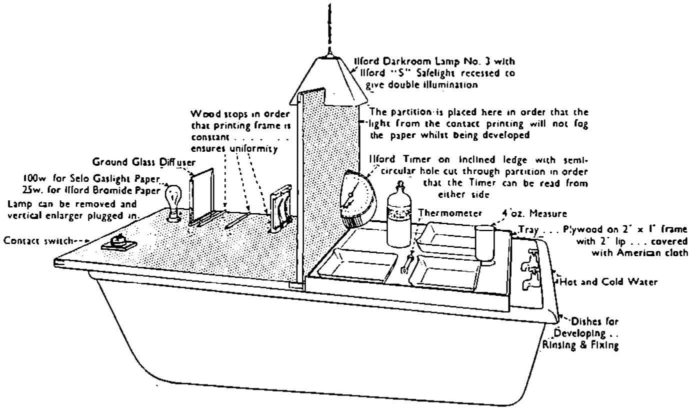


Fig. 70. A bathroom darkroom.

On the left-hand side of the bench a batten type lamp-holder is screwed down on to a wooden block to accommodate the exposing light, and it can also be used for connecting up a vertical enlarger. At measured distances from the light, wooden stops should be fixed one behind the other to ensure uniformity of distance in placing the printing frame.

If there is space available in the bathroom, a small cupboard should be fixed to contain the dishes, solutions, and other objects, so that the entire bench can be lifted off the bath and placed in any convenient position when not in use.

Much good work can be done in such circumstances, but, of course, where it is possible to furnish a room specially for photographic work, this is the better course. The size and lay-out of the darkroom will naturally depend upon the nature and amount of work to be undertaken. When the premises are being constructed specially for the purpose, it is possible to design them with a view to the nature of the processing operations with considerable gain in efficiency, but this opportunity rarely occurs, and one is most often faced with the necessity of converting old and sometimes quite unsuitable rooms. It is for this reason that standard darkroom lay-outs are not always as helpful as their designers would wish. The best that can be done is to lay down certain principles and to

illustrate one or two lay-outs which are capable of modification according to circumstances.

All darkrooms should be so arranged that one bench is kept dry, and upon this bench the sensitive material is handled while it is in the dry state. All wet operations are carried out upon a second bench (the wet bench) and in sinks conveniently placed. It must be impossible for splashes of working solution to reach the dry bench.

Similarly, the arrangements must be such that there can be no escape of solution from the hypo bath to the bench or floor. Negatives should never be taken from the bath for examination without previous rinsing, since this would certainly result in hypo contamination of the room, the equipment, and the sensitive material. Contamination of this kind is responsible for a large proportion of spoilt negatives and impermanent prints. No photographer worthy of the name should let any chemicals, particularly hypo, contaminate bench, floor, towels, or the fingers.

Two darkrooms are illustrated, the first being suitable for the enthusiastic amateur who is able to devote a corner of a room to his photographic work. The second scheme is a little more ambitious.

The darkroom shown, Fig. 71, 5 ft. 6 in. square by about 8 ft. high, could be built into a corner of the room or garage, or in the attic of a house.

Where a long and narrow space is all that is available, it would be necessary to put the wet and the dry benches end to end instead of at right-angles to each other.

The door could be in any of the positions shown at the top of the illustration, and the switch to the white light should be placed just inside the door, about 6 ft. up.

The dry bench, 2 ft. wide and 2 ft. 9 in. high, should run along one side of the wall. The last 18 in. of this length will be void and the rest divided up underneath into cupboards, shelves and drawers, for the storage of plates, paper, printing frames, etc. The cupboard door should swing back against the wall and not toward the sink.

On the other side of the darkroom is a porcelain sink, or alternatively a wooden sink lead lined. A standard size of sink $18 \times 30 \times 10$ in. is very convenient. This could be supported by pillars or angle brackets, the latter for preference, and should be of the type with an over-flow. A small standing waste should be provided to fit into the waste outlet.

Resting on the dry bench and on the edge of the sink is a teak draining board 19 in. wide, with a raised edge all round and with grooves on the top. On the right-hand side of the sink is a small draining board about 1 ft. wide. This would rest on a batten fixed to the side of the wall and on the top of the sink. Below the sink could be kept the waste bin, dish rack, and a stool.

About 26 in. above the level of the bench, and on both sides of the room, should be a shelf 8 in. wide. That above the wet bench

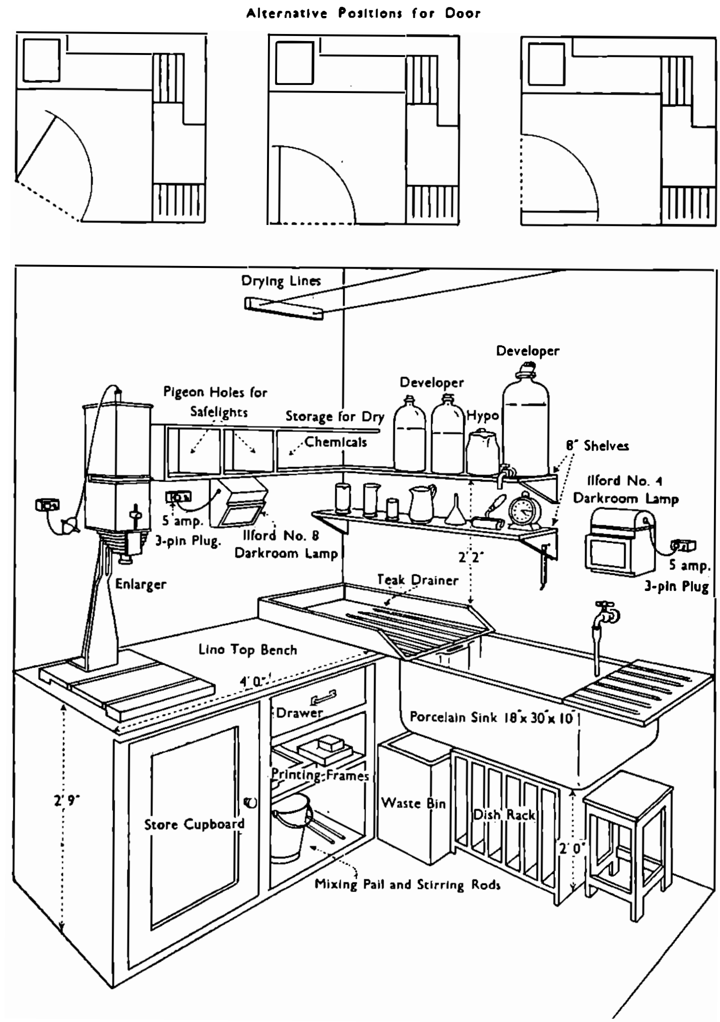


Fig. 71. Suggested arrangement for room 5′ 6″ × 5′ 6″ × 8′.

could be used for the stock solutions of developer and hypo. The former can be kept in winchesters or aspirators, and the latter in a wide-mouthed jug.

Below this shelf on the wet side (7 ins. below) is another shelf for holding graduates, darkroom clock, etc. Above on the dry side is another shelf, and the intervening space is made up into pigeon holes for the storage of safelights, dry chemicals, etc.

Below this shelf, above the dry bench, is an Ilford No. 8 Darkroom Lamp, which, as it can also be used as a retouching desk or viewing lantern, is ideal for such a darkroom.

A vertical enlarger can be placed on the dry bench on the left-hand side. These two fitments and the No. 4 Lamp above the sink are connected to 5-amp. three-pin plugs about 2 ft. above the bench level.

The Ilford No. 4 Lamp can be used to inspect negatives and prints after development, and safelights are easily changeable in either of the darkroom lamps mentioned.

Cold water at least should be available above the sink, and hot water also if there is a convenient supply. If not, a further plug point should be available under the shelf above the wet bench for the use of an immersion heater.

The bench and dish rack can be made of any ordinary soft wood, but the top of the dry bench should be covered with some thick good quality plain linoleum.

The walls should be painted in some pastel colour such as primrose yellow or a light green, and the floor should be rendered waterproof.

Scheme II. The two figures 72 and 73 show the wet and dry benches of a darkroom 10 ft. long, and with a minimum width of 7 ft. An extra foot in the width adds greatly to the convenience.

The wet bench is divided into two sections; on the left is a large lead-lined sink, and on the right a teak draining board. The sink is preferably teak with the lead seams burnt in, although white wood and soldered seams would be permissible. Both sides of the sink are fitted with a teak duck-board to hold developing and fixing utensils.

Three tanks, for developing, rinsing, and fixing of flat films and plates, are on the extreme left, and next to this is a space for the developing dish for prints, etc. The other duck-board carries a larger trough or dish for the fixing of prints. The sink should be fitted with a standing waste pipe so that it can be used for washing prints. Alternatively, a print washer may be kept in the sink.

Above this sink should be fixed two cold taps and one hot water tap, the cold taps both having swing arms. A towel rail on the front of the sink is a convenience.

Below the left-hand side of the sink is a raised duck-board for the storage of developing and fixing solutions, etc. Next to this is a bin for waste and a rack for dishes.

Below the draining board to the right-hand side is a series of shallow shelves to hold chromium glazing sheets. The squeegeeing operation can be carried out on the draining board, and here also plates may be drained and dried in a rack.

Below the shelves are stored the mixing utensils and a small cupboard to hold scales and dry chemicals.

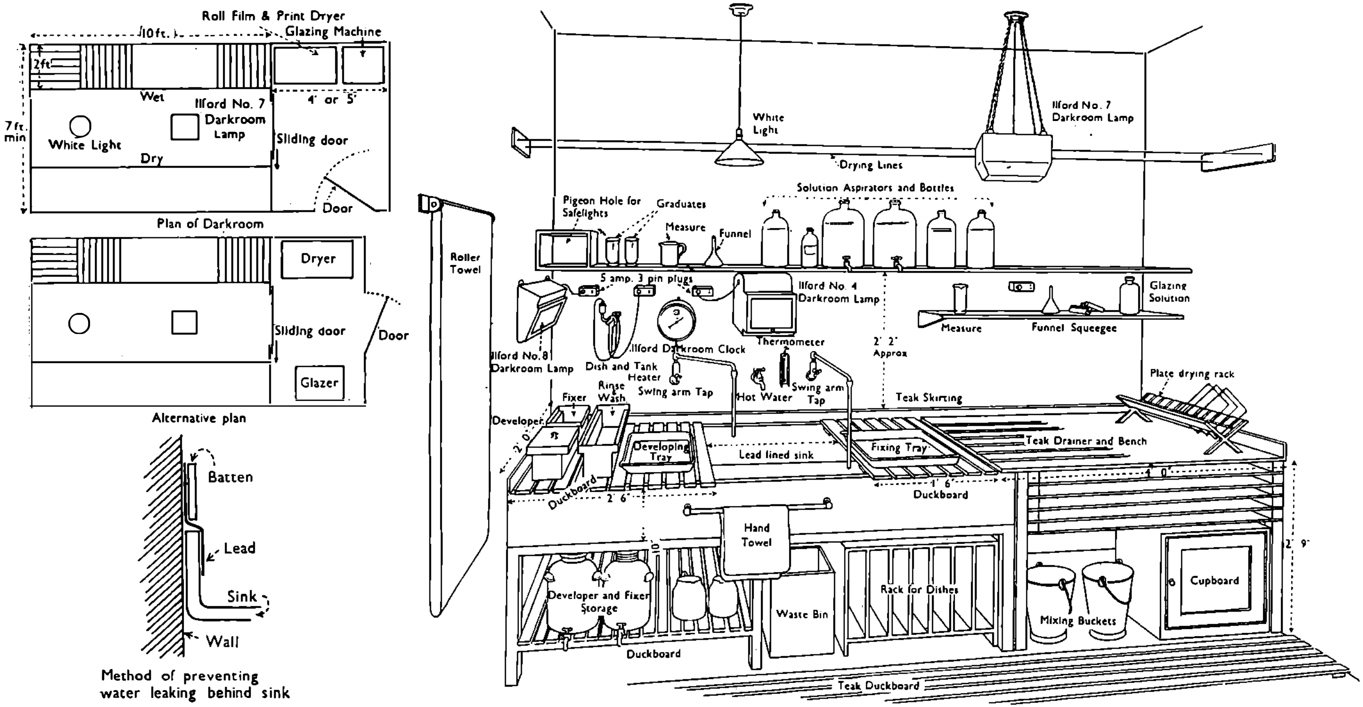


Fig. 72. Suggested lay-out for commercial darkroom—wet bench.

In front of the wet bench is placed a teak duck-board. A teak skirting is fixed round the wall next to the sink and draining board, and in the vicinity of the sink a lead insert is fitted to prevent leaking of solutions behind the sink (see plan Fig. 72). A roller towel should be fixed on the wall adjacent to the bench.

Above the whole wet bench is fixed a 10-in. wide shelf to hold such things as safelights, graduates, funnels and storage aspirators and winchesters, and another smaller shelf above the draining board only, to hold the necessary requisites for glazing.

Above the sink are also fixed No. 4 and No. 8 Darkroom Lamps and an immersion heater for dish and tank use, all of these being connected to 5-amp. 3-pin sockets. In this section, also hung on the wall, are a development timer and a thermometer.

Finally, above the bench are stretched two wires for the drying of roll films, if a drying cabinet is not available.

We now come to the dry bench, 10 ft. long, with a top made of teak, or white wood covered with linoleum, Fig. 73. This bench has provision for the storage of plates, papers, films, chemicals, printing frames, etc.

Skirting the wall and the bench is a hardwood batten to prevent chipping of the wall. A vertical enlarger is placed on the left-hand side and is connected to a 5-amp. 3-pin plug socket.

A shelf is fixed above the bench with pigeon holes for the storage of safelights, dark slides, etc. This bench is lit by means of two

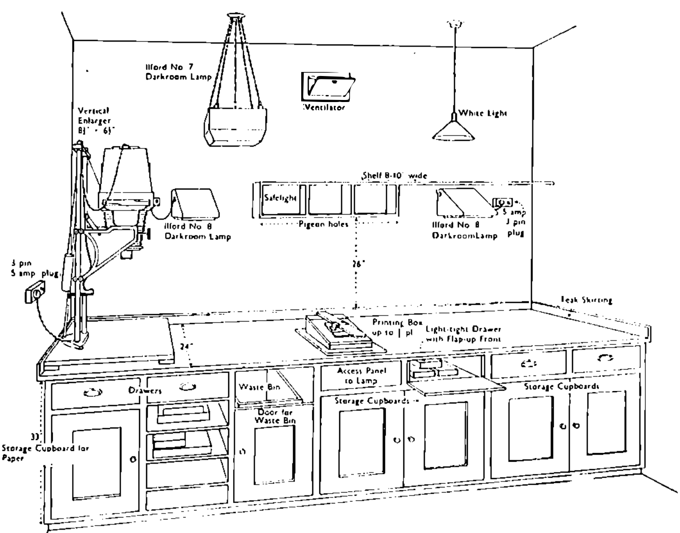


Fig. 73. Suggested lay-out for commercial darkroom—dry bench.

No. 8 Darkroom Lamps, one for use with the enlarger and printing box, and the other for the loading up of dark slides and hangers. These two lamps are also connected to 5-amp. sockets.

The printing box is let into the middle of the bench with an access panel below for servicing the lamps. This panel, and the one adjacent, take the place of the usual drawers.

The second panel has a flap-up front and should be made light-tight for the storage of paper in current use, or it can be fitted with pigeon holes to hold the paper out of the boxes.

The entrance lobby to the darkroom, which should constitute a light-trap, can also contain the film and print drying cabinet and glazing machine. Two suggestions are shown for the plan of the darkroom. (Fig. 72.)

List of materials suitable for the construction of darkroom equipment

(This list does not include fitments, *e.g.*, sinks, taps, etc.)

The materials normally available for constructional work include:—

A.	1.	Nickel	Metals
	2.	Zinc	
	3.	Aluminium	
B.	1.	Stainless Steels	Alloys
	2.	Monel Metal and Copper Alloys	
C.	1.	Plated Metals	Treated Metals
	2.	Japanned Metals	
	3.	Enamelled Metals	
D.	1.	Ebonite, Celluloid, Plastics	Non-metals
	2.	Papier mâché and Wood	
E.	1.	Glass	Fused Ware
	2.	Porcelain and Earthenware	

In addition, a further class has to be considered covering materials used to form joints in apparatus:

F.	1.	Rubber	To be considered in so far as they affect performance of articles in which they are incorporated.
	2.	Solder	
	3.	Welds	

The above are to be considered in relation to the articles which may be made from them, bearing in mind particularly the nature of the solutions with which they are to be used. Processing solutions may be roughly classified as follows:—

W. Hot and cold developing and fixing solutions and water.

X. Water only.

Y and Z. Cold developing and fixing solutions and water.

In the table which follows:—

1. Denotes equipment available in materials mentioned.
2. Denotes equipment having satisfactory performance when made in any of these materials.
3. Denotes the best materials.

		A1	A2	A3	B1	B2	C1	C2	C3	D1	D2	E1	E2
W.	Mixing Utensils ...				3				2	3	2		2
	Funnels			1	3				2	2		3	2
	Storage Utensils ...								1	1	2	3	3
X.	Clips (Drying) ...	2			3	2	2				2		
	Washers and Racks	2	2		3		2	2					3
	Racks (Drying) ...						2	2			3		
Y.	Hangers and Clips ...	1		1	3	1	1			2			
	Dishes				3	1		1	2	3	1	3	3
	Tanks	1	1		3	1	1	1		3		3	3
Z.	Forceps				3		1			3			
	Paddles and Rods ...				3		1			3	2		
	Graduates				3				2	3		3	3

We will first consider GROUP "F":—

F.1. Rubber

This is met with in the form of gloves, watertight packings for developing tanks, tubing, etc. Cheap rubber which contains free sulphur and metallic sulphides must be avoided. The alkaline developer reacting with these impurities form alkaline sulphides which are strong fogging agents.

F.2. Solder

Solder joints are to be avoided where possible when the apparatus is to be used with developers, as the tin content will cause fog. Low tin content or tin-free solders should be used.

F.3. Welds

Spot welding in conjunction with tin-free solders is to be recommended, otherwise welded joints should be made with electrode of similar material. Occlusions should be ground away from the back of the weld. Steels containing columbium and molybdenum decrease corrosion by preventing segregations of carbon within the weld.

GROUP A.

A.1. Nickel

Of the three types in this group, nickel is preferable for general use, but must be kept scrupulously clean. This material is definitely attacked by developing solutions. It is, however, suitable for drying clips, washing tanks and washing racks.

A.2. Zinc.

Zinc is not to be recommended for use with any processing solutions. It is rapidly attacked by fixing solutions, especially acid fixers. When in contact with sodium bisulphite it forms sodium hydrosulphite which is a very bad fogging agent. If zinc washing tanks are used they should be liberally coated with cellulose enamel, as otherwise a white deposit is formed which will adhere to prints and films.

A.3. Aluminium.

Aluminium is not to be recommended—firstly, on account of flimsiness. Secondly, hangers which are made of this material are attacked by ordinary developers and definitely dissolved by developers containing caustic alkalis.

GROUP B.

B.1. Stainless Steels.

These are suitable for all the types of apparatus enumerated. Stainless steels with a basic 18/8 analysis (18 per cent. chromium, 8 per cent. nickel) and containing 2 per cent. to 4 per cent. of molybdenum are most resistant. The steel chosen should also have a low carbon content, less than 0·2 per cent., to avoid attack by acid solutions. The corrosion resisting properties of stainless steels reside mainly in the high polish of the surface, therefore, articles must be kept clean and unscratched.

B.2. Monel and other Alloys of Copper.

These materials can be recommended for drying clips, but not for apparatus used in developing and fixing baths. Their use for this purpose will result in severe chemical fog and rapid oxidation.

GROUP C.

C.1. Plated Brass and Ferrous Metals.

Such materials cannot be used in contact with processing solutions, but may be used in the washing operations. They are thus suitable for drying clips, drying racks, washing tanks and washing racks. With use the plating wears thin and the underlying support becomes attacked. Electrolytic action is also started between the plating and the body of the article.

C.2. Japanned and Cellulosed Metals.

These should only be used for the purposes enumerated under C.1, and for the same reason. When the spraying is chipped the underlying metal, usually zinc or tinned iron, becomes attacked. Cellulose spraying is not resistant to strong developers or fixing solutions, moreover the pigments used are easily discoloured upon long contact with developers and fixers.

C.3. Enamelled Steel and Aluminium.

As long as the surface is not cracked to reveal the supporting metal which would be attacked, materials in this class are suitable

for photographic purposes. However, prolonged contact with cold solutions, or hot solutions by themselves will etch the surface of the enamel. This renders the article difficult to clean. For this reason enamelled pans are not suitable for storage purposes.

GROUP D.

D.1.

Most articles in this class are satisfactory, but the nature of the use to which they are to be put makes it advisable to avoid those which are softened by heat or are inflammable. These articles are generally supplied black, because most other pigments are discoloured by photographic solutions. However, stains do not show up very well on a black surface, and for this reason such articles are often left uncleaned. Materials in this class are generally very brittle, but they do provide equipment most resistant to chemical attack. Hard rubber is perhaps the best material for large size tanks.

D.2. Papier Mâché and Wood.

Dishes made of papier mâché with a japanned surface are available, but are not to be recommended, because when the surface is damaged they become soggy and hold large quantities of solution. The best woods to use are box, beech, teak, and lignum vitæ. The last of these is especially suitable for taps to storage jars, etc., as it does not take up any moisture. Wood is suitable for drying clips, racks, stirring rods, and print paddles. However, as wood always holds back a certain quantity of solution, separate utensils should be used for developing and fixing. Avoid wood vats for the storage of fixing baths. Crystallization of the components in the fibre of the wood will cause disintegration.

GROUP E.

E.1. Glass.

Glass is good from the corrosion resistance point of view, but, of course, is very fragile. It is, moreover, liable to fracture if exposed to severe and sudden fluctuations in temperature.

E.2. Porcelain and Earthenware.

Porcelain is also resistant to chemical attack, but with use the glaze becomes crackled and solutions are absorbed by the porcelain body of the article. Unglazed or partially glazed earthenware should be definitely avoided. Porcelain finished white immediately shows up stain, and thus, for this reason, porcelain developing tanks are to be preferred to those of hard rubber.

FITMENTS

Proceeding with the consideration of the more permanent darkroom, fittings, and fixtures, firstly let us deal with sinks, which are available in a variety of materials.

Porcelain with a white glazed surface is easily kept clean, but is liable to crackle, and glass vessels are usually fractured if dropped into a sink made of this material. Therefore, a soft rubber mat, which must be frequently cleaned, should be placed in the bottom of the sink. An alternative to this is the use of a teak duck-board in the bottom of the sink. In all sinks, to prevent attack of the usual brass waste outlet, it is advisable to use a small standing waste and to keep the bottom of the sink permanently covered with water.

Wood sinks are not recommended, as the joints frequently part when the planks warp. However, small sinks of this material are permissible if the bottoms are permanently covered with water. Teak and pitch pine are equally good. The sink should be braced together with steel rods and not merely screwed together. Developing solutions containing caustic alkalis should not be used with wood sinks.

Wood sinks lined with lead are very good for photographic dark-rooms, but the lead must be reasonably pure (chemical lead) and of 4 or 5 lb. thickness. The seams, for preference, should be burnt in. Hard wiped solder joints are satisfactory if done by a competent plumber. If the sides of the sink are deep, the lead must be tacked to the wood with copper nails and wiped over. Lead is practically resistant to all photographic chemicals, but plating out will occur with spent hypo. This should not be removed, as otherwise the thickness of the lead will be rapidly decreased.

Steel sinks lined with hard or soft rubber are not generally available in this country, but are very suitable for photographic purposes. It is also possible to procure wooden sinks lined with soft rubber. Here, of course, any solvents such as benzene, which would dissolve the rubber, must be avoided.

Stainless Steel and Monel Metal sinks pressed from single sheets of material are available, but are not generally suitable for photographic purposes, as they are normally rather small. Those in monel are definitely not satisfactory. Stainless steel sinks are very suitable and resistant to all chemicals if kept clean. It is wise to avoid stainless steel sinks with arc welded or any other seams.

Benches

Teak, maple, and beech woods are most suitable for dry benches, but the surface must be rendered smooth. Soft woods such as deal and pine, which are very easily chipped, are not recommended except when covered with battleship linoleum, soft rubber sheeting one-quarter inch thick, masonite, or other hard pressed fibre board. Some laminated phenolic condensation products are very suitable for bench coverings (tufnol, bakelite, etc.). For wet benches teak is the best wood to use. However, where a clean white surface is desired the teak bench itself may be inset with vitrolite or pot opal slabs.

Floors

Requirements for a good floor are that it should be hard and waterproof. Concrete with a good smooth surface is quite satisfactory, but must be laid in one piece without any joins. All cement products are attacked in time by processing solutions. Red tiles, hard rubber tiles, terrazzo and mastic are all suitable. With regard to the latter, a composition which can vary, it must be remembered that the degree of hardness will vary directly with the percentage of sand present, also that the waterproof qualities will vary directly as the asphalt content. Mastic will yield under pressure, therefore all sinks and benches should be placed on concrete or metal piers directly in contact with the sub-structure.

Walls

Brick walls covered with a good quality plaster, and then coated with several coats of hard glossy enamel, are resistant to the attack of photographic chemicals so long as the surface itself is undamaged. Distempered walls are not good, as the underlying plaster will rapidly absorb any moisture. It is best, however, to face walls, where they may come into contact with solutions, with one of the following: terrazzo, vitrolite, or tiles. Bearing in mind that cement will in time be attacked, it is best to lay these in the largest size possible. A whole section of terrazzo can be laid without a join, and so this is preferable to pre-cast terrazzo tiles. Vitrolite is available in large sheets, ashlars and tiles. Large sheets should not be screwed to the wall, but fitted on with the recommended mastic cement. Vitrolite ashlars and tiles can be treated in the same way as ordinary porcelain tiles.

CHAPTER VIII

DEVELOPERS AND DEVELOPMENT

●

The action of the developer is to bring about the decomposition of light-struck grains of silver bromide to metallic silver. In other words, a developer is a member of a class of chemical compounds termed reducing agents. But not all reducing agents may be used as developers—only a few are able to distinguish between grains which have and grains which have not been light struck. With few exceptions, and those not of practical value, all organic developers are derivatives of benzene, toluene, naphthalene, or similar compounds obtained by the distillation of coal tar. Developers may be sought amongst all reducing systems where the reduction potential is less than 0·12 volt (Clerc), the reduction potential of a solution constituting a measure of the ability of that solution to take away the positive charge from the metal radicle of a salt in contact with the solution. For several reasons, however, it cannot be taken as a measure of developer activity. For one thing, it is not possible accurately to measure reduction potentials of developing solutions, but quite apart from this, developer activity is affected by a number of other factors, as, for instance, the manner in which the developing agent is adsorbed to the surface of the silver halide.

Developing agents are not used alone—the developing bath contains certain other constituents whose presence is essential for the proper functioning of the solution. The other constituents generally found are:—

(1) The alkali (normally sodium carbonate, but sometimes sodium hydroxide and sometimes borax) by means of which the activity can be accelerated.

(2) The preservative (normally sodium sulphite) which preserves the developer from premature oxidation.

(3) The restrainer—a soluble bromide, normally potassium bromide, which acts as a brake upon the activity of the developer. Some developers begin life without soluble bromide, but all contain it as soon as developing starts, since it is liberated in the process.

DEVELOPING AGENTS AND THEIR PROPERTIES

Metol (monomethyl-paraminophenol sulphate), a white crystalline powder readily soluble in water, but insoluble in a strong solution of sodium sulphite. In making up a developer containing metol this chemical should be dissolved first, together with a few crystals of the sulphite, in water at a temperature not higher than 125°F. (52°C.).

The small quantity of sulphite will prevent oxidation—the presence of a greater amount would make it very difficult to dissolve the metol.

Metol is described as a detail-giving developer. It causes shadow detail to come up fairly quickly, and without any alkali or with a mild alkali such as borax, metol provides a very useful range of fine grain formulæ.

Hydroquinone (quinol, para-di-hydroxy-benzene), fine white crystals, fairly soluble in water; 1 part hydroquinone dissolves in about 18 parts water. The dry substance should be kept well stoppered—there is just a slight tendency for it to become discoloured.

Hydroquinone gives contrast—the highlights come up long before the shadows. Metol and hydroquinone are commonly used together to provide a well-balanced developer for general purposes. Hydroquinone is inactive at low temperatures, *i.e.*, below 50°F. (10°C.).

Amidol (di-aminophenol), fine white or bluish-white crystalline powder, readily soluble in water. Amidol should be dissolved in a solution of sodium sulphite and no further additions need be made to provide a satisfactory developer. The solution of Amidol and sulphite, while not becoming discoloured to any extent, loses much of its developing power within two or three days. Also the developer, though not itself coloured, produces heavy bluish-black stains on fingers and nails. In the dry state Amidol is slowly affected by air and light. It should be kept in well-stoppered bottles.

Glycin (para-oxyphenylamino-acetic acid), white crystalline powder, very slightly soluble in water, but freely soluble in alkaline solutions. Glycin developer keeps better than any other, but, unfortunately, is too slow in action for general use. It is used in some fine grain developing formulæ of low energy. Glycin reacts markedly to the presence of bromide.

Paramidophenol (paraminophenol) is a developing substance which is almost exclusively used for compounding a highly concentrated developer in which the active agent is an alkali salt of paramidophenol, produced by the action of caustic alkali. The solution contains a certain excess of caustic alkali and is diluted with from 10 to 30 times its bulk of water to form the working developer.

Chlorquinol (monochlorquinol; also known under the German trade name of Adurol), is very similar to hydroquinone.

Paraphenylene diamine (diaminobenzene). Many popular "fine grain" developers consist of paraphenylene diamine and sodium sulphite with varying concentrations of glycin. Paraphenylene diamine itself is poisonous, but it forms complexes with certain other developing agents and some of these complexes are stated to

be non-poisonous and free from other disadvantages of para-phenylene diamine itself. One such addition compound is Meritol.

Pyro (pyrogallic acid, tri-hydroxy-benzene) is sold in a compact white form and also as bulky light feathery crystals, one ounce of which fills a 10-oz. bottle. Pyro, which is very poisonous, is very soluble in water; the solution rapidly turns brown on exposure to the air and after some time becomes muddy from formation of an insoluble compound. If the solution is alkaline, this change takes place in a few minutes. Hence pyro developers are compounded with a large quantity of preservative. Even so, they tend to give an image in which a certain amount of brownish stain is combined with the silver. Solution which has become discoloured likewise stains the entire coating of gelatin on a negative.

Pyrocatechin (ortho-dihydroxybenzene). This developing agent is used to provide (*a*) tanning developers, and (*b*) extra rapid developers containing caustic alkali.

While the foregoing are the developers most commonly used, mention may be made of others less frequently employed. Ferrous oxalate, at one time universally adopted for bromide papers, is obtained in solution by adding a saturated solution of ferrous sulphate to about six times its volume of a saturated solution of neutral potassium oxalate. The deep red mixture is an excellent developer for plates, since it is non-fogging and yields an image entirely free from stain. Plates must, however, be exposed for a longer time than when using any of the ordinary present-day developers.

ALKALIS IN COMMON USE IN DEVELOPERS

The alkali most largely used is **sodium carbonate,** of which there are three forms available commercially: crystals (decahydrate) containing 37 per cent. of carbonate; monohydrate, containing 85 per cent. carbonate; and dry, or anhydrous, containing practically 100 per cent. carbonate. The monohydrate has the advantage of being more stable and more easily dissolved. One part of the anhydrous may be replaced in formulæ by 2·7 parts of the crystals (decahydrate) or by 1·17 parts of the monohydrate. Ordinary washing soda is an impure form of crystal sodium carbonate, and should not be used in place of the pure form prepared for photographic use. The "carbonate of soda" sold as a white powder by grocers is a different substance (sodium bicarbonate) and is useless as the alkali of a developer. For high contrast it is usual to utilize developers containing sodium or potassium hydroxide—the developing agent being hydroquinone. These alkalis are very strong and they have a very corrosive action upon the skin. If caustic alkali gets upon fingers or clothes the affected parts must be washed immediately in cold water. Bottles containing solid caustic alkali or a solution

should have rubber stoppers, since glass stoppers would stick, due to the formation of carbonate. In the high sulphite, low energy class of fine grain developers, of which Ilford ID-11 is an example, borax is the common alkali. Such developers may be buffered, *i.e.*, balanced at any degree of activity by choosing suitable quantities of borax and boric acid. Some active developers use potassium carbonate, which should be purchased only as anhydrous and should be kept securely corked. If left exposed to the air it rapidly becomes damp or even semi-liquid, in which state its strength is greatly reduced.

Other Alkalis

Ammonia, once exclusively used as the alkali for the pyro developer, has long been abandoned, except for very special purposes, *e.g.*, in reversal developers, because of its variable strength and a liability to cause fog, due to its solvent action on silver bromide. Tri-basic sodium phosphate is a substance which is partly decomposed by water, with formation of sodium hydroxide, and thus yields a "caustic" developer in a mild form. Acetone decomposes sodium sulphite, with liberation of sodium hydroxide, and has been employed as a substitute for the usual alkalis in development. Formalin also reacts with sodium sulphite to form sodium hydroxide and is also used as the source of alkali in certain developers. Recently the use of sodium metaborate has been advocated in certain formulæ. Identical results are obtained by the use of equal parts of sodium hydroxide and borax.

PRESERVATIVES

These serve the purpose of preventing the developing substance from becoming discoloured whilst in stock solution and during the course of development, and are necessary for obtaining negatives free from stain. Sodium sulphite and potassium metabisulphite are chiefly used.

Sodium sulphite is sold both in crystal and in anhydrous forms, one part of the latter being equal to two parts of the former. The crystallized sulphite should be in clear, almost transparent, crystals. If coated with a powdery incrustation, the crystals should be quickly rinsed in a very little cold water and mopped dry on a clean cloth or blotter before weighing out. Crystal sulphite dissolves most freely in water at about 100°F. (38°C.). The dry or anhydrous sulphite is obtained as a powder which dissolves readily in water. Supplies of either form should be kept in a well-closed container.

Potassium metabisulphite, when freshly made, is in transparent crystals, but usually has a slight opaque incrustation which, however, does not denote deterioration to any appreciable extent. In the dry state metabisulphite keeps very much better than sulphite. It dissolves fairly readily in tepid water, forming an acid solution

smelling of sulphurous acid. As a preservative of pyro in stock solution, metabisulphite is as effective as at least four times the quantity of crystallized sodium sulphite, since its slight acidity has a preservative effect in addition to that of its sulphite content.

RESTRAINER

Although other substances (potassium citrate, sodium bicarbonate) act as restrainers, potassium bromide is the only one in general use as an addition to the stock solution of the developing substance or as a separate 10 per cent. solution for addition to the developer as required.

WATER FOR DEVELOPERS

There is one remaining element in the composition of a developer, *viz.*, the water in which the chemicals are dissolved. While distilled water, on account of its purity, is the best for the purpose, its superiority does not justify its extra cost. The mineral salts present in even hard tap water are without effect, except that they may give rise to a slight cloudiness in solutions containing sodium carbonate or other alkali. Frequently this will settle out as a deposit, but if it does not it is of no account. The chief objection to tap water is dissolved air, which tends to cause oxidation and also to form air-bells on the emulsion surface, which prevent development. The air can be expelled by boiling the water briskly for 5 or 10 minutes in a clean enamel saucepan, and with many town waters this operation also throws down a large part of the dissolved lime salts. If the water is put on one side to cool (it need not be filtered), it is as suitable as can be desired for making up stock solutions and for diluting them.

MAKING UP DEVELOPERS

Developers are normally handled in three strengths, (*a*) as stock solution, (*b*) at dish strength, and (*c*) at tank strength. Tank strength is usually half dish strength.

Formulæ should be made up exactly to manufacturers' instructions and it is well to use that recommended for the plate or film in question.

In general, the reducers are dissolved first in water at about 125°F. (52°C.), containing a pinch of sulphite to prevent immediate oxidation. It is impossible to add all the sulphite at this stage, because of the difficulty of dissolving metol in sulphite solutions. The sulphite should be dissolved as soon after the reducers as possible and may even go in before the hydroquinone. Then, after the reducers and the sulphite have been dissolved the carbonate is added and, finally, the bromide. For small quantities it is convenient to dissolve all the ingredients in correct order in three-quarters of the final volume, making up afterwards with cold water.

For larger quantities it is wise to dissolve the chemicals separately, each in a small quantity of water. The separate solutions are then added one to another, again in the correct order.

Stirring greatly facilitates solution. When large quantities of chemicals have to be dissolved they may be contained in a cloth bag suspended from a stick placed across the mouth of the vessel. It will be found that this method brings about complete solution very quickly and prevents solutions being used while they still contain solid particles—a frequent cause of scratched negatives and spots.

PROCESSING UNDER TROPICAL CONDITIONS

Rate of development increases rapidly with increasing temperature but the rate of change is vastly different with different developing agents. Temperatures above 70°F. (21°C.) should be avoided wherever possible because:

(1) fog becomes troublesome unless it is held back by the addition of extra bromide;

(2) at high temperatures the gelatin of the emulsion may soften and tend to leave the base unless special precautions have been taken in manufacture or by the user.

It is realized, however, that in tropical countries it is often necessary to process plates and films at elevated temperatures and for such circumstances the following techniques are recommended.

All solutions and washing water should be as nearly as possible at the same temperature, as variations of temperature between these are more liable to cause frilling, blisters, or reticulation than a uniform higher temperature. For instance, it is usually unwise to use a developer approaching 80°F. (27°C.) and a fixing bath which has been freshly made up with cold water.

Almost any recognized developer will give satisfactory results with Ilford materials if the time of development be suitably adjusted for the temperature. At high temperatures the time of development may be inconveniently short, when it is better to increase the amount of the potassium bromide in the developer rather than to dilute with water. The bromide content may be increased to double the quantity recommended for 65°F. (18°C.) or with a developer containing metol to several times if the temperature is very high.

For development at high temperatures, from 75°F. (24°C.) to 90°F. (32°C.) add to the developer sodium sulphate (Glauber's salt) in the proportion of 3 ounces to each 20 ounces of developer mixed ready for use. This has no adverse effect on development. It does not harden the gelatin, but it prevents it swelling in the developer. The material is then rinsed quickly and fixed in the fixing and hardening bath, or it may be hardened in a solution of formalin (40 per cent. solution) 1 part, water 100 parts, and then fixed in an ordinary fixing bath.

For development at temperatures over 90°F. (32°C.) the method described above may be employed, but it is safer to use the Ilford Tropical Hardener according to the issued instructions. Alternatively, the material may be hardened before development by immersion for 3 minutes in the following solution, after which processing may be carried on as in temperate conditions with the usual developer and fixing bath. (Ilford Tropical Hardener is supplied in 3-oz. and 10-oz. bottles.)

Sodium sulphate (Glauber's salt) ..	4 oz.	or	100 g.
Formalin (40 per cent. solution) ..	½ oz.		12·5 c.c.
Water, up to	20 oz.		500 c.c.

This or the Ilford Tropical Hardener may also be used at any temperature, but should be rather more dilute at lower temperatures.

After fixation the plates or films should be well washed, but must not be left an unnecessarily long time in the wash water, taking into consideration that the fixing salts are removed more quickly when the temperature of the water is high than when it is low. Drying should be conducted as rapidly as possible, preferably in a current of air.

DESENSITIZATION

When development is being carried out in a dish or open tank it may be controlled by inspection and stopped when it is considered to have gone far enough. This involves visual examination which is extremely difficult by the feeble light permitted, even with only moderately fast materials unless they have first been specially treated. Such treatment is known as desensitization.

Certain substances exist which have the power of reducing very considerably the sensitivity of the silver halide grains without seriously injuring the latent image produced by previous exposure. By bathing the exposed plates in a solution of one of these substances it is possible to carry out development immediately afterwards in a fairly bright light of suitable character.

Ilford Limited manufacture two desensitizers—Qualitol and Desensitizing Yellow—and full instructions are issued with each. Where a fine grain developer is to be used, Desensitizing Yellow is recommended.

If desensitization has been carried out using one or other of these chemicals, the plates or films may be developed in the light transmitted by the Ilford Bright Green Safelight No. 909.

THE TECHNIQUE OF DEVELOPMENT

By the older school of photographers development was regarded as something of an art, in the exercise of which much could be done, by using more or less of one constituent or another, to obtain the finest quality of negative or to make amends for errors in exposure or deficiencies such as lack or excess of contrast in the subject. This

art was based almost entirely on the use of the pyro developer with ammonia as the alkali. There was something to be said for this point of view, because in those days printing papers were available only in one contrast and it was necessary to produce a negative having a density range to suit. This, of course, no longer applies. It is now agreed that tinkering with developing solutions makes very little difference to the quality of badly exposed negatives and the tendency is certainly towards standardization upon formula, time and temperature. At the same time it is well to remember that a negative which is seriously over-exposed for development in a straight M.Q. formula may give satisfactory results in, say, paraphenylene diamine and that even after a negative is processed something can still be done to it by suitable after-treatment.

The manipulation of the sensitive material depends largely upon its nature. Plates, flat films, and roll films each require very different methods of handling.

Plates, because of their rigidity, can be handled with ease and may be developed lying flat in a dish, emulsion upwards, or suspended vertically in suitable hangers in a tank. For dish development the best practice is to place the plate in the empty dish and to flood it with developer swiftly but carefully. Unless the surface is wetted quickly and evenly, developing marks will certainly result. During dish development the dish must be rocked in two directions at right angles to provide agitation. In tank development agitation is usually provided by lifting the plates from and replacing them in the bath at short intervals. Previous wetting of plates prior to development is not recommended. Unless it is done very thoroughly it tends to encourage uneven development instead of preventing it.

Flat films may be developed like plates in a dish, but they are best handled in tanks suspended in hangers of special design. The same recommendations with respect to agitation apply.

Roll films may be developed by hand in an open dish, using the see-saw method. Here prior wetting is definitely recommended to reduce the tendency to curl. The best practice is the following:

Assuming we are to develop a No. 20 roll film, $3\frac{1}{4}$ by $2\frac{1}{4}$ inches **(not panchromatic)**, it is desirable to have 10 ounces of the developer in a deep half-plate dish; as little as 6 ounces of solution *can* be used, but it is then necessary to have a smaller dish. When the darkroom is ready the spool is unrolled as far as the end of the sensitive film, which is then made to take up into a roll in the left hand, while the right hand continues the unrolling. In this way the spool paper passes *over* the left hand and so into a waste bin; the film is thus shielded from light (see illustration, p. 190). This is accomplished by the sense of touch rather than of sight, and the knack is most useful on other occasions, as when panchromatic films have to be dealt with in darkness or in the minimum of safelight.

STEPS IN THE DEVELOPMENT OF A ROLL FILM

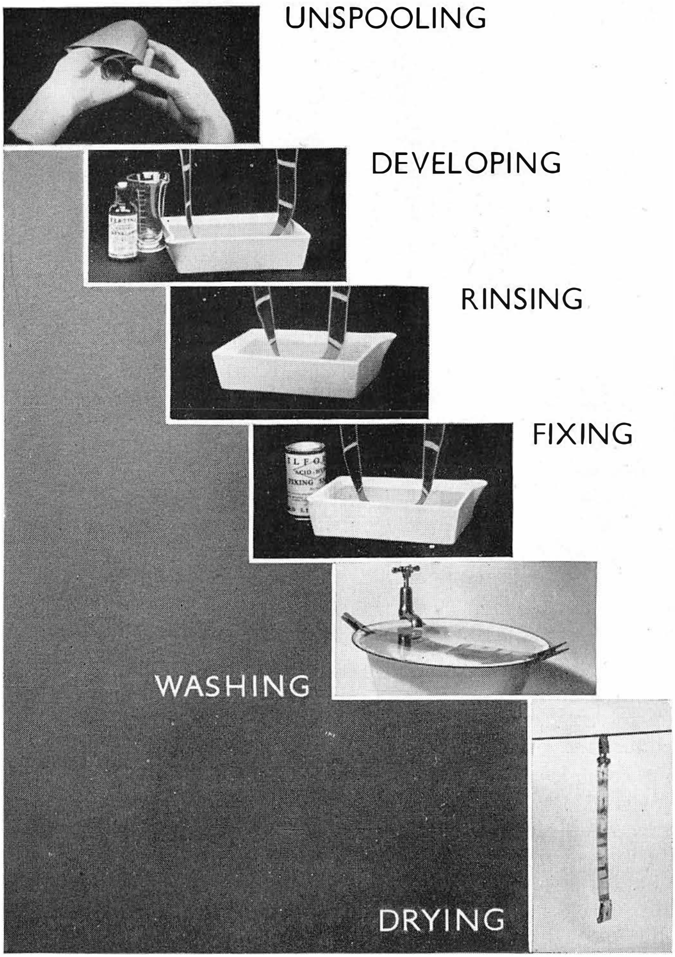


Fig. 74.

The film is "springy" and for convenience in handling should be evenly wetted and made limp before developing starts. A dish containing clean water should have been placed some distance from the

darkroom lamp and now the film is drawn out straight between the hands (care must be taken not to touch the sensitive surface at any stage before or during development) and the end in the left hand pushed beneath the water, while the film is kept straight by curving it slightly across its width. Next, still keeping the film straight, the right hand is lowered while the left is raised; in this way a bend is made in the film beneath the water and with two or three such movements the film becomes limp and "manageable."

Now a non-corroding clip is fitted to each end of the film, which should not be touched by hand again.

The film is drained for a moment and transferred to the developer, through which it is drawn in see-saw fashion, care being taken that the film is evenly and completely covered by the solution.

The above should have been done as far from the darkroom lamp as is consistent with seeing what one is doing. A position about 2 ft. to one side or the other of a lamp fitted with the Ilford Iso Safelight No. 906 will provide adequate lighting of a safe character, and the dish should be kept there until development is nearly finished.

The image should first make its appearance after about half a minute in the developer, this time giving an indication that the film has received approximately the right exposure. A better indication, however, is the order in which different parts of the picture become visible. If the highlights (*e.g.*, sky) appear first and are followed gradually and steadily by the half-tones, and then by the darker parts of the subject, it may be taken that exposure has been reasonably correct.

When the highlights are slow in appearing, and the darker tones are also much slower in showing plainly, the film has been under-exposed. If, on the other hand, highlights come up in appreciably less than half a minute, with half-tones showing almost at the same time, the film has been over-exposed.

Development continues until it is judged that the process has gone far enough. But it is not very easy for a beginner to know when this point is reached. In general, the deepest shadows of the subject (the lightest parts of the negative) should show a slight greyish veil (with detail visible) when looking at the negative in the dish, and if the negative, when held up to the darkroom lamp (not too near), also appears almost opaque in the highlights, development may be considered to be sufficient. One method of judging the end-point of development is to observe the appearance of the back of the film, development being regarded as complete when the highest densities appear black, but this method may fail if double-coated or heavily-coated materials are being used. At this stage, the edges of the negative, where the emulsion was protected from the action of light by the mask of the camera, should be almost white. If they are greyish, it is a sign that the emulsion is beginning to fog, and that development should not be continued longer.

In some cases, we may wish to get more contrast than the subject would yield if developed "correctly," *e.g.*, scenes photographed in dull weather or under flat lighting. Longer development, short of fogging, will do this, and though the result can never equal that from a subject which is properly lighted, it is often improved.

Development having been judged sufficient, the film is rinsed in water for a few seconds before being fixed.

The foregoing method of development by inspection is not suitable for the development of panchromatic materials, owing to their sensitivity to light of all colours. The dim green light which may be used in the darkroom should be employed solely to illuminate the clock, and not as a light by which the partially developed material may be inspected—this will lead, almost certainly, to fogging.

TANK DEVELOPMENT OF ROLL FILMS

There have been many different types of tanks specially designed for roll films, some intended for daylight loading. Others have involved darkroom loading, but have been suitably light-trapped to make it possible to carry out the actual developing process in the light. Most of these have accommodated the film in the form of a spiral coil and many devices have been employed to keep the various coils separate. One of the earliest of these took the form of a celluloid apron which had to be wound up with the film. Projections along the edges maintain contact with the film and prevent contact over the picture area. Now it is more common to wind the film into a special holder comprising a spool having wide flanges, the inner surfaces of which bear spiral grooves. The Ilford Adjustable Tank is of this type, and can accommodate all sizes from 35 mm. miniature films to No. 16 roll films.

This tank is essentially a miniature darkroom; once the film has been loaded into it, all processing operations and the removal of the film may be carried out in full daylight. Only the actual loading of the tank must be done in the dark. For this purpose no elaborate darkroom is required—a cupboard can be used—but remember that very little light indeed is necessary to fog modern high-speed films. If the smallest chink of light is seen the room is unsafe. It is permissible, of course, to use a suitable safelight during the loading operation, but on the whole it is best to practise loading lengths of old film until one becomes so familiar with the operation that it is easy to repeat it in total darkness. The atmosphere of the room in which loading is done should be free from dust.

The Ilford tank is designed to accommodate films of different widths, the position of one section of the film holder being adjustable for this purpose. This section is held in one of four notched positions and can easily be moved from one to the other. Care must be taken when making this adjustment to avoid the use of force.

Note.—When using 35 mm. film make sure that the movable part of the film holder is correctly engaged in the lowest notch. If this position is passed and the movable portion pushed right down (a further short distance), the distance between the flanges will be insufficient and the film will jam.

The minimum quantity of developer necessary varies according to the width of the film, and this information is given on the instruction leaflet supplied with the tank.

LOADING

Remove the lid of the tank and draw out the spiral film holder. Adjust the film holder as already described until the spiral tracks are in the correct position to suit the width of film which is to be developed. At this stage the film holder must be perfectly dry. If a film has recently been developed in the tank and the holder is still wet, every part of the spiral tracks must be carefully dried before any further work is done. The next step is to remove any paper which may be attached to the film—miniature films may have leaders and trailers of paper and roll films will have the normal duplex backing paper. Paper leaders should be discarded immediately, and with roll films the duplex paper should be unwound until the end of the film is reached. The duplex paper should be allowed to fall clear as the film is fed into the tank, and when the end of the film is reached the duplex paper should be detached completely and discarded.

For the actual loading the best procedure is as follows:—Cut off the corners of the leading end of the film, bend the end backwards to remove the curl and then enter it into the slot openings at the beginning of the parallel spiral tracks. The openings may be recognized in the dark by the lugs which project beside them. Feed the film gradually into the spiral, allowing the film holder to oscillate slightly. It may be necessary to assist the entry of the film by feeding it forward with the first finger on the celluloid surface. If the film should stick, tap the film holder gently on the palm of the hand. When loading is complete, the end of the film is inserted in the back stop to prevent its re-emergence from the spiral, the film holder is placed again in the tank and the cover put on and locked in position by turning in a clockwise direction. At this stage the tank may be taken into the daylight.

The developer is introduced into the tank through the central funnel. During development the solution should be agitated at frequent intervals and this is done by means of a twirling rod which is inserted through the central opening to engage the cross member in the film-holder spindle. A gentle rotation from time to time in an anti-clockwise direction is all that is required.

The time and temperature of development should be controlled according to the directions given by the manufacturers of the

sensitive materials—for temperature control a thermometer may be inserted in the central opening of the tank. After development is complete the solution should be poured from the tank by the spout at the side. Thereafter the tank should be filled and emptied twice with clean water. Throughout these operations, of course, the lid must remain securely in position. After the tank has been emptied the second time it should be filled with the fixing solution, again as recommended by the film manufacturer. Ten to fifteen minutes should be allowed for fixation, and during this time the film holder should be rotated once or twice by means of the twirling rod. After this period has elapsed the fixing solution should be poured from the tank which should then be placed under a running tap. Again the water should enter the central hole; the jet should not be too fierce and the washing should be continued for at least half an hour. Alternatively, and if running water is not available, the tank should be filled and emptied with clean water at least ten times, allowing a few minutes to elapse between each filling and emptying.

The film must not be pulled from the spiral tracks. The film holder should first be taken to pieces and the film removed as carefully as possible. It should then have a clip attached to each end and be hung vertically in a warm, clean atmosphere and allowed to dry. The tank should now be thoroughly washed, wiped, and placed in the air to dry. It is important that this drying should be thorough and that the wiping should not leave traces of fibrous material in the spiral grooves. Heat should not be used to speed up the drying operation since this might cause the tank to warp.

Tanks as just described are particularly suitable for miniature films, when it is important that the film shall bear no blemish, however small. With the "fine grain" developers recommended, development times are of the order of 10 to 15 minutes.

For tank work and, when panchromatic materials are employed, for dish development also, the time and temperature method is the rule and all manufacturers supply convenient tables by means of which the correct development can quickly be determined. It is clear that the degree of agitation which is given can make a very considerable difference to the development time required to give a certain contrast, but with one or two trials based on the manufacturer's tables one can soon get the type of negative required. If one chooses to work from published characteristic curves (see Chapter III), one should normally add 50 per cent. to the times there given for any particular gamma, as the curves are usually produced under conditions of brush development where agitation is of a particularly high order.

The Ilford Time and Temperature Tables are given on page 195. The times given indicate the development necessary to get the contrast usually required with the plate or film in question, *i.e.*, gamma 0·8 for portrait negatives and 1·1 for landscape work. Fine grain work

usually necessitates a gamma of 0·65, and this is normally achieved by development of Selo Miniature Films in ID-11, using the times indicated in the tables for developers at tank strength.

DEVELOPMENT TABLE FOR PLATES AND FILMS

MATERIAL	DISH Ilford M.Q. Ilford Pyro Soda and Certinal Developer			TANK Ilford M.Q. Ilford Pyro Soda and Certinal Developer		
	55°F. 13°C.	65°F. 18°C.	75°F. 24°C.	55°F. 13°C.	65°F. 18°C.	75°F. 24°C.
PLATES	min.	min.	min.	min.	min.	min.
H.P.3	7½	5	3½	15	10	7
Hypersensitive Panchromatic	6½	4½	3¼	13½	9	6½
F.P.3	4½	3	2	9	6	4
Press Ortho Series II	4½	3	2	9	6	4
Selochrome	5½	3½	1½	11	7½	3¾
Golden Iso-Zenith	11	7½	5	22	15	10
Soft Gradation Panchromatic	8¼	5½	3½	16½	11	7
Special Rapid Panchromatic ...	4½	3	2	9	6	4
Press (Ortho)	6	4	3	12	8	6
Iso-Zenith	8¼	5½	3½	16½	11	7
Zenith 700	9	6	4	18	12	8
Auto-Filter	4¾	3¼	2¼	9½	6½	4½
Special Rapid	4½	3	2	9	6	4
Chromatic	3¾	2¼	1¾	7½	4½	3¼
Empress...	3	2	1½	6	4	3
Infra-Red (with filter)... ...	5¼	3½	2¼	10½	7	4½
Ordinary	3	2	1½	6	4	3
FLAT FILMS						
H.P.3	5¼	3½	2¼	10½	7	4¼
Portrait Panchromatic ...	9	6½	4½	18	13	9
Hyperchromatic	9	6	4½	18	12	9½
Portrait Ortho Fast	9	6	4½	18	12	9½
Commercial Ortho	4½	3	2¼	9	6	4½
Fine Grain Ordinary	3	2	1½	6	4	3
ROLL FILMS						
Selo H.P.3	7½	5	3½	15	10	7
Selochrome	7½	5	3¼	15	10	6½
Selo Fine Grain Panchromatic	5¼	3½	2¼	10½	7	4½
Selo Ortho	7½	5	3¼	15	10	6½
Selo Infra-Red with filter ...	5¼	3½	2¼	10½	7	4½

The times given are *approximate* only and depend also on the subject, the lighting, and the printing paper to be used.

This table is not intended to apply to the developers used in the photo-finishing trade, except at the concentrations given above.

Note.—Ilford M.Q. Borax Fine Grain Developer ID-11.—The tank times given above will give soft negatives with this developer suitable for enlarging on to a normal grade of bromide paper

providing adequate exposure has been given and that the subject is of average type. To produce more vigorous negatives these times may be increased by as much as 50 per cent.

WATKINS' FACTOR

When a plate has been normally exposed, the development time necessary to produce any given degree of contrast (gamma) in a specified developer can be expressed as a multiple of the time taken for the first appearance of the image. This rule was laid down by Alfred Watkins in 1893 and has been used with great success. Various tables have been computed giving values for the Watkins' Factor for different developing agents and here we quote one from *Photography, Theory and Practice* (Clerc).

Hydroquinone	5
Pyro with bromide	4–9
Pyrocatechin	10
Glycin with soda carbonate	8
Glycin with potassium carbonate	12
Paramidophenol	16–20
Amidol	18
Metol	30

The factor is not very much affected by changes in proportions of developer constituents, dilution or temperature changes. Bromide content affects the factor only in noticeable degree in the case of pyro developers. Unfortunately, the very general use of fast panchromatic materials with which development by inspection is impossible has somewhat reduced the value of the Watkins' Factor as a guide to consistent development. We should mention also that the use of a desensitizer usually affects the factors very considerably.

DEVELOPER FORMULÆ FOR NEGATIVE WORK
M.Q. DEVELOPERS

ID-2. Metol-hydroquinone (M.Q.) developer

For plates and films. Negative developer.

STOCK SOLUTION

		or
Metol	20 gr.	1 g.
Sodium sulphite (cryst.)	3 oz.	75 g.
Hydroquinone	80 gr.	4 g.
Sodium carbonate (cryst.)	2 oz.	50 g.
Potassium bromide	20 gr.	1 g.
Water, up to	20 oz.	500 c.c.

Dish: For use dilute 1 part with 2 parts of water.
Tank: ,, ,, ,, 1 ,, ,, 5 ,, ,, ,,

Although specially designed for gaslight paper and gaslight lantern plates, the following developers are extremely useful as

general developers for all plates, films and papers and give good detail and contrast:—

ID-29. Metol-hydroquinone developer

Metol	15 gr.			0·75 g.
Sodium sulphite (cryst.)	1 oz.			25 g.
Hydroquinone	60 gr.			3 g.
Sodium carbonate (cryst.)	$1\frac{1}{2}$ oz.		or	40 g.
Potassium bromide, 10 per cent. solution (pot. brom. 1 oz., water to 10 oz.)	1 dram			3 c.c.
Water, up to	20 oz.			500 c.c.

ID-36. Metol-hydroquinone developer

Metol	56 gr.		3 g.
Sodium sulphite (cryst.)	4 oz.		100 g.
Hydroquinone	$\frac{1}{2}$ oz.	or	12·5 g.
Sodium carbonate (cryst.)	$7\frac{1}{2}$ oz.		187·5 g.
Potassium bromide	32 gr.		15 g.
Water, up to	80 oz.		2000 c.c.

For plates and films use at half strength. The dish times on page 195 are suitable.

All the above formulæ contain two reducing agents, *viz.*, metol and hydroquinone. They are non-staining, they keep well and they can be prepared in the form of concentrated stock solutions to be diluted for use.

When negatives are known to be under-exposed, use ID-2 (stock solution diluted 1–5) at 70°F. (21°C.). When negatives are known to be over-exposed, use the developer at this concentration at 65°F. (18°C.) and double the amount of potassium bromide. Increase development time to compensate.

OTHER DEVELOPERS

Amidol is little used for negative work owing to the fact that in solution it keeps badly. The formula given below keeps only one or two days and is best used on the day of making. It tends to give soft negatives.

ID-9. Amidol

This is a good all-round developer. It requires no alkali but the sulphite is essential.

Sodium sulphite (cryst.)	4 oz.		100 g.
Amidol	175 gr.	or	9 g.
Potassium bromide	50 gr.		2 g.
Water, up to	20 oz.		500 c.c.

This developer is used at the strength given above. It is suitable for dish development only, but the development times required are those quoted on page 195 for tank work.

This developer keeps only for a day or two, any left over being useless.

Glycin developer

This developer keeps excellently; is stainless and non-fogging. It is, however, very slow.

Glycin developer ID-10

Glycin	1 oz.	or	25 g.
Sodium sulphite (cryst.) ..	1½ oz.	or	40 g.
Potassium carbonate (anhyd.) ..	5 oz.	or	125 g.
Water, up to	30 oz.	or	750 c.c.

For use dilute with an equal volume of water.

For dish development with this developer increase the tank times given on page 195 by 25 per cent.

If potassium carbonate is not obtainable, satisfactory results can be obtained by the use of twice the weight of sodium carbonate cryst.

Pyro-metol developer

This developer, in the absence of sulphite, gives a very yellow image and is most useful in cases of great under-exposure, as the usual lack of density which would be given with a non-staining developer such as metol-hydroquinone is compensated for in printing by the colour of the image. For these reasons, and also because of its rapid action, it is a great favourite among press photographers, whose negatives usually must yield prints or enlargements which are distinctly hard, so as to yield satisfactory vigour when reproduced with the coarse screens employed for half-tone blocks in newspapers. The yellow stain can be lessened if required by the addition of 2 oz. sodium sulphite (cryst.) to 20 oz. of the B solution (20 per cent. sodium carbonate).

Pyro-metol developer ID-4

A. Pyro Solution

Metol	35 gr.	or	2 g.
Potassium metabisulphite ..	100 gr.	or	6 g.
Pyro	100 gr.	or	6 g.
Water, up to	20 oz.	or	500 c.c.

B. Sodium Carbonate Solution

Sodium carbonate (cryst.)	4 oz.	or	100 g.
Water, up to	20 oz.	or	500 c.c.

For use, mix equal parts of A and B.

The development times recommended are 75 per cent. of those quoted for dish development in the table on page 195.

Pyro-soda developer

This developer took the place of the old pyro-ammonia formula and has given excellent service. Although it is not so widely used nowadays it is such a classic that a fairly full account of its use is

necessary. This is taken directly with certain deletions and modifications from an earlier edition of this Manual.

This developer may be made up from the chemicals or may be purchased in "Tabloid" form as "Tabloid pyro-soda developer" (Ilford formula). The pyro is kept in a stock solution, *viz.*:—

Pyro-soda developer ID-1

PYRO STOCK SOLUTION

Pyrogallic acid	1 oz.	or	25 g.
Potassium metabisulphite	100 gr.		6 g.
Water, up to	10 oz.		250 c.c.

Dissolve the metabisulphite before adding the pyro. This solution will keep in good condition, as shown by its pale yellow colour, for several months.

WORKING SOLUTIONS

A. Pyro stock solution, as above ..	2 oz.	or	50 c.c.
Water, up to	20 oz.		500 c.c.

Sufficient of this solution is made up at the time of use or for a day's work.

B. Sodium carbonate (cryst.) ..	2 oz.	or	50 g.
Sodium sulphite (cryst.) ..	2 oz.		50 g.
Potassium bromide (10 per cent. solution)	2 drams		6 c.c.
Water, up to	20 oz.		500 c.c.

Dissolve the sulphite and carbonate in 15 oz. (350 c.c.) of water about as hot as the hand can bear (100°F., 38°C.), add the bromide solution and make up to 20 oz. with cold water. This solution should be kept in a bottle with rubber stopper; a glass stopper is liable to stick; the solution keeps fairly well in a well-corked full bottle, but not very well in the presence of air, as in a half-empty bottle.

The developer is made up, just before placing the plate or film in the dish, by mixing equal quantities of A and B. The quantity of each chemical per oz. (or per 100 c.c.) of the developer will then be as follows:—

	In 1 oz.		In 100 c.c.
Pyro	$2\frac{1}{4}$ gr.	or	0·5 g.
Potassium metabisulphite	$\frac{1}{2}$ gr.		0·12 g.
Sodium carbonate (cryst.)	22 gr.		5 g.
Sodium sulphite (cryst.)	22 gr.		5 g.
Potassium bromide ..	$\frac{1}{4}$ gr.		0·06 g.

These quantities may be said to represent a normal pyro-soda developer suitable for the development of practically any plate or film which has been correctly exposed.

For the best results the developer should be used at a temperature of about 65°F. (18°C.).

Let us assume that a non-panchromatic plate is being developed. About half a minute will elapse, if the plate has been correctly exposed, before the outlines of the subject are visible. If the high-lights (*e.g.*, sky) appear first and are followed gradually and steadily by the half-tones and then by the darker parts of the subject, exposure has been reasonably correct.

A correctly exposed plate is allowed to continue developing with constant rocking of the dish until it is judged that the process has gone far enough, *i.e.*, until the deepest shadows of the subject (the lightest parts of the negative) show a slight greyish veil (with detail visible) when the negative is viewed in the dish.

Under-exposure. If the image takes a minute or more to appear in the above developer at the proper temperature, and if then the darker tones fail to show soon after the high-lights, we can be sure that exposure has been too short. The developer is at once poured off and the plate flooded with 3 or 4 oz. of plain water. The object is to use a developer in which the highlights will gain density much more slowly, and so allow time for detail to come up in the under-exposed parts. Nothing will make a good job of under-exposure, but a diluted developer, with addition of metol solution, will improve matters. To the developer already used, add an equal bulk of water (*i.e.*, 3 oz. or 80 c.c.)—or more, if the plate seems badly under-exposed—and also some of the C or metol solution in proportion of 1 dram (3 c.c.) to each ounce (25 c.c.) of original developer, *viz.*, 3 drams (9 c.c.) in this case. Pour off the water and apply this diluted developer. There is no harm, but some advantage, in using warm water for diluting the developer, but the temperature of the diluted solution should not exceed 70°F. (21°C.).

SOLUTION C—METOL SOLUTION

Metol	100 gr.	or	6 g.
Sodium sulphite (cryst.)	1 oz.	or	25 g.
Water, to make	10 oz.	or	250 c.c.

This weak pyro-metol solution is allowed to act on the plate or film. Notice if detail in the less exposed parts makes its appearance, and continue development as long as there is any improvement in this respect, but usually not longer, since the highlights will certainly be quite dense enough, if not too dense. The process will generally be much slower than normal development and may require 10 or 15 minutes or more. Hence the dish should be covered with a piece of cardboard and the negative examined from time to time without taking it out of the dish, until it is judged that no further detail is making its appearance in the shadows.

Over-exposure. If the image appears in less than half a minute and then comes up rapidly in all parts, the plate is over-exposed. If

greatly over-exposed, the image will appear almost as soon as the developer is poured on.

Excessive exposure, as shown by rapid appearance and flatness of the image, requires prompt treatment. Pour off the developer and, without intermediate rinsing, flood the plate with some of the A pyro solution and let it remain in this solution while a modified or fresh developer is made up. Because of the presence of alkali in the gelatin and adhering to the dish the plate will continue to develop but at a much reduced rate.

As a rule it will be sufficient to add extra bromide to the developer already used, *viz.*, 1 dram (3 c.c.) of D solution to each ounce (25 c.c.)—in this case 3 drams (9 c.c.).

D. BROMIDE SOLUTION (10 per cent.)

Potassium bromide	1 oz.	or	25 g.
Water, up to	10 oz.		250 c.c.

Pour off the A solution, apply the mixture, with the extra bromide added, and allow development to continue. In the case of great over-exposure the negative usually becomes so dark and dense that one cannot judge of its contrast when looking at it in the dish or through it when held up to the safelight. Nevertheless, let it develop further for, say, a couple of minutes after it has darkened all over. When it has been fixed it will be much easier to judge how best to reduce it, whereas it is not at all easy to improve an over-exposed negative which has not been thoroughly developed.

In extreme cases of over-exposure it may be well to add some extra pyro as well as the bromide. This may be done by adding a little of the pyro stock solution, each 10 minims of which contain about 1 grain of pyro (0·6 c.c. contains 0·06 g.). The quantity of the pyro in the developer may be brought up to 5 grains per ounce (1·2 g. per 100 c.c.) by adding 25 minims per ounce (1·3 c.c. per 25 c.c.), so that for 3 oz. (80 c.c.) of developer about $1\frac{1}{4}$ drams (4 c.c.) of the strong pyro solution will be added. The larger proportion of pyro makes the developer "harder" in working and thus helps to give the desired contrast, but it must never be forgotten that this "tinkering" with the developer cannot yield results approaching reasonably correct exposure and normal development.

ID-35. Hydroquinone carbonate developer

Hydroquinone is a good developer when made up with sodium carbonate as in this formula, for plates which have not been under-exposed, and excellent for known over-exposure when used with half the amount of sodium carbonate, giving negatives which with almost any other developer would be considerably lacking in contrast.

ID-35

A

Hydroquinone	3 oz.	or	75 g.
Sodium sulphite (anhyd.)	7½ oz.		188 g.
Potassium bromide ..	¾ oz.		18 g.
Water, up to	80 oz.		2000 c.c.

B

Potassium carbonate (anhyd.)	10 oz.	or	250 g.
Water, up to	80 oz.		2000 c.c.

For use, take equal parts of A and B.

ID-13. Caustic-hydroquinone developer

For its special purpose of giving negatives of extreme contrast, as in copying line drawings, etc., hydroquinone is best compounded with caustic potash plus a large quantity of bromide. This formula has been designed for Ilford Process and Half-tone Plates, and serves well for other slow plates, such as are generally used for copying line originals.

ID-13

A. Hydroquinone Solution

Hydroquinone	1 oz.	or	25 g.
Potassium metabisulphite	1 oz.		25 g.
Potassium bromide	1 oz.		25 g.
Water, up to	40 oz.		1000 c.c.

B. Caustic Potash Solution

Potassium hydroxide (stick or pellet)	2 oz.	or	50 g.
Water, up to	40 oz.		1000 c.c.

For use, mix equal parts of A and B.

The developer acts quickly, yielding great density in about 3 minutes.

A point to note in using hydroquinone is that negatives should be thoroughly rinsed between development and fixing, otherwise indelible yellow stains are liable to occur.

ID-3. Metol

Gives soft gradation with maximum shadow detail. Development is slow, but the speed may be modified by altering the dilution.

ID-3

Metol	50 gr.	or	3 g.
Sodium sulphite (cryst.)	1 oz.		25 g.
Sodium carbonate (cryst.)	2 oz.		50 g.
Potassium bromide	10 gr.		0·5 g.
Water, up to	20 oz.		500 c.c.

For use, dilute 1 part with 3 parts of water. With this developer at the strength indicated the development times advised are 25 per cent. longer than the "Tank" times quoted on page 195.

Certinal is a highly concentrated developer of the paramidophenol type made in solution form by Ilford Limited. For use, 1 part is mixed with from 10 to 30 parts of water, according to requirements. For normal exposures on plates and films, 1 part is mixed with 15 parts of water, and at this strength the developer acts as a normal M.Q. developer at dish strength. For tank development use 1 part with 30 parts water and give the tank development times shown on page 195. A strength of 1 : 20 is suitable for under-exposures, and one of 1 : 10 for over-exposures, with the addition in the latter case of 1 part of 10 per cent. potassium bromide solution. Certinal is a developer which brings up all parts of the image quickly; density grows slowly in developers not stronger than 1 : 20, and, owing to the stainless character of the depth of the deposit, requires to be greater than would appear necessary. Owing to its concentration, good keeping qualities and adjustability for errors in exposure, Certinal forms a most convenient developer for the amateur. For the benefit of those susceptible to skin poisoning, it may be mentioned that Certinal does not contain metol.

FINE GRAIN DEVELOPERS

These fine grain developers fall into three main classes as follows:—

(1) **Metol-hydroquinone-borax developers** characterized by low alkalinity and high concentrations of sodium sulphite. The Ilford ID-11 formula is a typical example. This developer produces low contrast and maximum shadow detail with negative materials and, in general, produces finer grained images than are obtainable with an ordinary developer. Its use is to be recommended as a good standard developer for all miniature camera negatives.

FINE GRAIN DEVELOPER ID-11

Metol	20 gr.	or	1 g.
Sodium sulphite (cryst.)	4 oz.		100 g.
Hydroquinone	50 gr.		2·5 g.
Borax	20 gr.		1 g.
Water, up to	20 oz.		500 c.c.

Time of development is from 10–20 minutes according to the plate or film being developed and the contrast required. For further information see Time and Temperature Table, page 195.

(2) **Para-phenylene diamine developers** consist of para-phenylene diamine and sodium sulphite with varying concentrations of glycin. These developers produce brownish images, show a very considerable reduction in grain, but require an increase in exposure of from

$1\frac{1}{4}$ to 4 times, according to the type of negative material used. The most generally useful of these developers is the well-known Sease III developer, which is to be recommended when very considerable enlargement showing minimum grain is required.

SEASE III DEVELOPER

Sodium sulphite (cryst.)	$3\frac{1}{2}$ oz.	or	90 g.
Glycin	50 gr.		3 g.
Para-phenylene diamine (free base)	100 gr.		5 g.
Distilled water, to..	20 oz.		500 c.c.

The chemicals are dissolved in water at about 125°F. (52°C.) in the order stated and then filtered. The time of development varies from about 10–25 minutes at 65°F. (18°C.), according to the type of negative material used.

(3) The third class of fine grain developers, known as **Physical Developers,** contain silver in solution. The developed image consists of finely divided metallic silver deposited on the latent image from the silver in solution, instead of being derived from the silver bromide of the emulsion. The best known formulæ are due to Dr. Odell or are derivatives of these formulæ, and they give extremely fine grained images which are much less dependent on the type of negative material used. These developers, however, have only found a limited application because they are rather difficult to use.

It is important to realize that any number of developers can be produced from the basic types by making small changes in the formulæ, but generally speaking little is to be gained by making such changes. For instance, in the ID-11 type the hydroquinone could be omitted or replaced by glycin or chlorquinol. In this type of formula the identity of the alkali can also be varied with little noticeable effect provided that its amount is kept low. Borax may thus be replaced by a small quantity of sodium carbonate, say 1 gramme to the litre, or tribasic sodium phosphate may be used.

The addition of boric acid provides a developer which is less affected by changes in the alkalinity of the water with which it is made up.

One advantage of the ID-11 type of formula is that no increase in exposure is necessary; another is that the development times are convenient. The scope of the developer is not limited to miniature work; it is quite suitable for use as a general negative developer, and it is quite cheap to make up. This is an important point and it is probably for this reason more than any other that this is the only type of fine grain developer which has achieved popularity for commercial finishing.

With the second group of fine grain developers a very striking improvement in graininess is obtained compared with an ordinary developer, but a fairly considerable increase in the exposure is necessary. In general, those which give the minimum graininess require the greatest increase in exposure. Again, the maximum contrast obtainable with these developers is rather low and development times tend to be long.

Before concluding this section mention should be made of certain fine grain formulæ which contain silver halide solvents such as hypo, thiocyanate, etc. A very simple and cheap fine grain developer is obtained by adding ammonium chloride to a developer of low alkalinity, *e.g.*, ID-11 in the proportion of about 35 to 45 g. per litre of working strength solution. There is naturally some decrease in effective emulsion speed, but a formula of this kind gives results comparable with the Sease No. III developer both in the matter of speed and graininess. When used with a super-speed film such as the Selo H.P.3 it gives a graininess comparable with Selo Extra Fine Grain Panchromatic developed in ID-11. Another very economical fine grain developer can be made by adding Ammonium Chloride to ID-2 developer in the proportion of 10 g. per litre. This formula is no more costly to make up than an ordinary M.Q. developer, which makes its use quite suitable for the commercial development of miniature films. Unlike paraphenylene diamine these developers are non-toxic and the formulæ are simple to make up.

Finally, mention should also be made of the Ilford Extra Fine Grain Developer ID-48, which is available in convenient packings with complete instructions for making up and for use.

SUBSTITUTION OF CHEMICALS

Generally speaking, sodium and potassium salts may be substituted for each other in most formulæ with complete success, provided that chemically equivalent quantities are employed.

The figures set out in the following table have been checked and found to work well in practice.

For 100 parts by weight of potassium	bromide use 87 parts of sodium bromide.
,, ,, ,, ,, ,, ,, ,,	metabisulphite use 85 parts of sodium metabisulphite.
,, ,, ,, ,, ,, ,, ,,	hydroxide use 100 parts of sodium hydroxide. In this case the molecular equivalent quantity of sodium hydroxide, *viz.*: 70 parts, is not sufficient and would result in considerably reduced activity.

AMOUNTS OF DEVELOPER REQUIRED FOR SINGLE PLATES OR FILMS AND APPROXIMATE FIGURES FOR THE NUMBERS OF PLATES, FILMS AND ROLL FILMS WHICH MAY SAFELY BE DEVELOPED IN CERTAIN VOLUMES OF DEVELOPER

Plates and flat films developed in the dish

For one plate or film in the appropriate sized dish:—

$4\frac{1}{4} \times 3\frac{1}{4}$ in.	$1-1\frac{1}{2}$ oz.	30 – 40 c.c.
$6\frac{1}{2} \times 4\frac{3}{4}$ in.	2–3 oz.	55 – 85 c.c.
$8\frac{1}{2} \times 6\frac{1}{2}$ in.	4 oz.	85 – 110 c.c.

It should be possible to develop about 36 $\frac{1}{4}$-plates in 15 oz. of dish strength developer.

Plates and flat films developed in the tank, developer at tank strength

It is normally possible to develop:—

Without replenishment	80 $\frac{1}{4}$-plates per 50 oz. of developer.
With replenishment	120 $\frac{1}{4}$-plates per 50 oz. of developer.

Roll films developed in the dish, developer at dish strength

It is normally possible to develop four No. 20's (or four 36-exposure lengths of 35 mm. film) per 20 oz. of developer.

Roll films developed in the tank, developer at tank strength

It is normally possible to develop:—

Without replenishment	100 No. 20 films per gallon of developer.
With replenishment	150 No. 20 films per gallon of developer.

These figures presume that the development time is gradually increased to offset the reduced activity of the developer.

REPLENISHING

Developers should not be overworked. For the amateur it is a good rule to discard developer after it has been used once. In the case of the professional who handles large quantities of material it is necessary to be more economical. He may regularly discard a portion of his bath (up to one-third), replacing it with fresh developer, developer minus bromide or with a modified formula, according to the advice of the author of the formula.

Ilford Limited issue details of replenishing solutions for several of their formulæ and pack one special developer, Ilford Long Life, ID-46, complete with several units of replenisher.

CHAPTER IX

FIXING, WASHING, AND DRYING

After development the plate or film is fixed, but it is bad practice to transfer directly from the developing bath to the fixing solution. Commonly, a short rinse is given in clean water and this is often all that is necessary, but a better technique involves the use of an intermediate acid stop bath, the function of which is to neutralize the alkali in the developer carried over in the emulsion layer. The action of the stop bath is to arrest development and it also tends to prolong the life of the fixing bath. It is of particular value when a highly alkaline developer, such as caustic hydroquinone, has been used. Although the bath must be acid it must not cause precipitation of sulphur from the fixing bath, and this rules out the stronger acids. Solutions of potassium metabisulphite ($2\frac{1}{2}$ per cent.) or acetic acid (1 per cent.) are commonly used.

Occasionally a hardening stop bath containing $2\frac{1}{2}$–3 per cent. chrome alum is employed. This is particularly desirable when processing is being carried out at high temperatures, since the gelatin is hardened before it has had time to swell excessively.

The developed negative bears the silver image, but it is not yet in such a condition that it may be brought into the daylight or be used in the further operation of making the positive print. The silver halide which was not affected by exposure and which has not undergone reduction by the developer still remains in place, lowering the contrast of the negative and increasing the density of the image. This silver halide is still light sensitive and would gradually print out, changing colour and masking the image to a greater and greater extent as time went on. The remaining silver salt must therefore be removed and this is done in the fixing bath, which is in fact a solvent bath for silver halides. Of the possible solvents, sodium thiosulphate (hypo) is the one in general use—all the others have disadvantages of one kind or another. The alkali cyanides and thiocyanates, for example, although more rapid in action than hypo, exert a softening action on the gelatin and have a fairly considerable solvent action on the silver image. The cyanides have the additional disadvantage of being highly poisonous. They have been and still are generally used, however, in the Collodion process.

Hypo itself has a weak solvent action on the silver image and while its action is negligible during the time required for fixation, prolonged immersion in the fixing bath results in considerable reduction in density, and the effect may be very marked where fine grain negative emulsions and printing papers are concerned.

The fixing bath removes the residual silver halides by transforming them into soluble double salts of sodium and silver which must

themselves be removed from the emulsion. Some of them are not particularly soluble and, in addition, tend to break down to form silver sulphide. This is one reason why fixing baths should not be worked to exhaustion point—such baths would contain a certain amount of these unstable compounds and although they might be capable of dissolving silver halide they would leave the film with a very high concentration of the soluble double salts, including the unstable ones from the effect of which it might not be possible to free the film by subsequent washing. The practice of using two fixing baths, the last being relatively fresh, has much to recommend it.

For rapid fixing the optimum concentration of hypo crystals is approximately 40 per cent. (8 oz. per 20 oz. solution). Speed of fixation also increases with temperature, but wherever possible it should not be allowed to exceed 68°F. It is obvious that in tropical countries this condition cannot be complied with, but for such circumstances special processing instructions have been provided and no undue difficulty will be met with if the directions given are followed exactly (see page 187). The addition of ammonium chloride to hypo baths to speed up fixing has been advised but the procedure is of doubtful value.

The hypo should be dissolved in hot water, since the formation of the solution is accompanied by a considerable fall in temperature. If cold water is used to begin with the crystals will dissolve only very slowly and the bath will have to be warmed again before use. Where large quantities are involved the hypo may conveniently be placed in a muslin bag suspended just below the surface of the water. This method hastens solution and obviates any need for stirring.

Plain Hypo Baths. These are seldom used, since unless a satisfactory stop bath has been employed there is very considerable danger of the gelatin becoming stained due to the oxidation of developer carried over in the emulsion layer. It is more common to use an acid fixing bath which may be regarded as a combined stop bath and fixing bath, or an acid hardening-fixing bath, which is still more satisfactory. Such baths are described in the following pages. A plain hypo bath is, however, used when it is desired to get the maximum amount of staining with a Pyro developer (and also for certain kinds of paper). With plain hypo baths the white light must not be turned up until fixation is complete.

Acid Fixing Baths. The addition of a suitable acid to the hypo solution provides a more satisfactory fixing bath, since it prevents any danger of stain from the oxidation of developer carried over into the fixing bath. At the same time it arrests development immediately. Under these conditions white light may be turned up shortly after the sensitive material has been placed in the fixing bath. Acid fixing baths should be discarded as soon as they show any sign

of depositing sludge upon the film or as soon as they become excessively turbid. Most acids cause hypo to decompose with the formation of a precipitate of sulphur which can only be brought into solution again by boiling with sulphite. The presence of sulphite in the solution, however, tends to prevent the formation of this precipitate, and so acid fixing baths are made up

(1) by the addition of sodium bisulphite or potassium metabisulphite to the hypo solution *when the latter is cool.*

(2) by the addition to the hypo solution of sodium sulphite together with a weak acid such as acetic acid.

A very useful bath has the following composition:—

Hypo	1 lb.	or	400 g.
Potassium metabisulphite	1 oz.	or	25 g.
Water to	40 oz.	or	1000 c.c.

The hypo is dissolved in 30 oz. of hot water. The temperature falls considerably during this process. The metabisulphite is added to the cool solution and the volume is finally adjusted by the addition of water.

Acid Hardening-Fixing Baths. When for any reason it is necessary to process in warm solutions or to carry out rapid drying by the application of heat, it is essential to harden the gelatin and this can conveniently be done by means of a good acid hardening-fixing bath. Even at ordinary temperatures the use of such a bath has many advantages:—

(1) The hardened gelatin is less easily damaged in the subsequent operations.

(2) Hardening reduces the drying time considerably and enables air at a much lower temperature to be used without thereby increasing the drying time.

(3) Hardening results in the production of more consistent negatives, since the final density obtained is less dependent upon the drying conditions (temperature and humidity).

(4) Hardening reduces washing time.

(5) Hardening gives clean negatives free from deposit due to hard water.

Particularly when processing miniature films a hardening-fixing bath should be used to minimise the danger of damaging the negative. Greater care is necessary in making up a combined hardening-fixing bath than a normal acid fixing bath, but provided that the instructions are closely followed, no difficulty should be experienced. Again, a hardening-fixing bath should not be used to exhaustion because of the danger of scum forming upon the negative.

Permanent tanning of the gelatin is usually effected by means of potash or chrome alum. The latter gives a greater degree of hardening when the bath is freshly made, but unfortunately the hardening

properties diminish with age whether the bath is in use or not and there is also a tendency to form a coloured scum on the negative as the bath nears exhaustion point. Potash alum fixing baths, although giving less hardening when freshly made up, have therefore much to recommend them. The formulæ of acid hardening baths are more complicated than those of ordinary acid fixing baths and the following facts have to be taken into account:—

(1) Potassium alum reacts with most photographic developers, forming insoluble aluminium salts which, if allowed to remain in the bath, would deposit on the gelatin of the negative when dried as a white scum.
(2) There are certain fairly well defined limits of acidity beyond which potassium alum will not harden.
(3) Normally within these limits of acidity hypo is decomposed with the production of clouds of sulphur.
(4) Alkaline developer carried over in the gelatin layer will rapidly tend to neutralize the acid of the hardening-fixing bath to limits beyond those of efficient hardening.

The following acid hardening-fixing bath is recommended:—

Hypo	12 oz.	or	300 g.
Sodium sulphite (cryst.)	350 gr.		20 g.
Boric acid	87 gr.		5 g.
Glacial acetic acid	192 m.		10 c.c.
Potash alum (cryst.)	½ oz.		12·5 g.
Water, to	40 oz.		1000 c.c.

Note on the preparation of acid hardening-fixing baths. The hypo should be dissolved in about one-third to one-half of the final volume of *warm* water. The sulphite and boric acid should then be added and completely dissolved. The solution, if still warm, should then be cooled to about 70°F. (21°C.) and the acetic acid diluted with four times its volume of water before being added to the hypo, sulphite, and boric acid mixture, stirring the bath during this addition. The potash alum is then dissolved in about one-fifth of the total volume of warm water and the solution added to the rest of the ingredients, *stirring all the time*, at a temperature below 70°F. (21°C.). It is most important that these solutions be mixed at a temperature not in excess of 70°F. (21°C.). The volume is then adjusted with more water.

N.B.—It is important that the acetic acid should be diluted in a vessel free from traces of hypo, as this acid readily causes sulphurization when added to hypo in the absence of sulphite.

TIME OF FIXATION

The time required for fixation, which should be approximately twice the time required for clearing, depends upon the following factors:—

(1) Type of emulsion and thickness of coating—fine grain emulsions fix more rapidly than coarser grain ones.

(2) Type and degree of exhaustion of the fixing bath—a concentration of 30–40 per cent. (Crystals $Na_2 S_2O_3 \cdot 5H_2O$) gives the most rapid rate of fixation, concentrations above or below this value give slower rates of fixation.
A partially exhausted bath fixes more slowly, not only on account of reduction in concentration of hypo, but also because of the accumulation of potassium iodide from emulsions containing iodide.

(3) Temperature of the bath—increase of temperature gives increased rate of fixation. It is desirable, however, to maintain the temperature of the fixing bath between 65°–70°F. in order to avoid excessive swelling of the gelatin before it is hardened, and prolong the life of the fixing bath. Its temperature should also be within a few degrees of the development temperature to avoid the danger of reticulation of the gelatin.

(4) Degree of agitation—agitation materially reduces the time of fixation. Agitation is also desirable when processing at high temperatures to avoid scum marks on the film on account of the necessary short rinse between development and fixation.

WASHING

The purpose of the washing operation is to remove all the soluble salts left in the emulsion layer after fixing. If fixing has been thorough and the fixing bath in good condition, quite a short wash will suffice, but if fixing has been inadequate no amount of washing will bring the negative into a condition in which permanence is assured.

Glass negatives may be washed in several ways, the choice depending upon whether only one or two or a large number must be handled simultaneously. A single negative placed under a gentle spray of water from a rose will be washed in three or four minutes. The plan of placing negatives in a shallow inclined trough, down which water runs from a perforated tube at the upper end, is nearly as expeditious. Both, however, are wasteful of water. Where consumption of water is a consideration, and many plates are to be washed, the best appliance on the whole is the tank fitted with a siphon, by which the water running into the tank from a tap is almost completely drawn off every time the tank becomes full. A loose rack will accommodate a dozen or more negatives, and patterns may be obtained which take several sizes.

Flat film negatives should be kept in their hangers for washing, and treated in a tank with a siphon.

Roll films which have been dish developed by the see-saw method may be stretched out base side downwards in shallow trays with

weights at each end to keep them from curling. Films which have been developed in the various types of daylight loading tanks may usually be washed in position in the tanks. This applies to miniature films particularly, which are usually too long and too springy to be handled by the see-saw method. If it is necessary to wash such a film by hand the best practice is to allow it to form a close coil. With the left finger and thumb forming bearings upon which the coil can rotate, the outer end of the film is from time to time pulled out as far as possible and then allowed to come back, the coil being reformed in the process by the natural curl of the film.

For efficient washing, running water is usually advised, the reason being that this ensures fresh water being continuously brought to the gelatin surface. In practice, the method is very wasteful and equally satisfactory washing can be obtained by using several changes. The removal of hypo from an emulsion layer is a simple process of diffusion of soluble salt from the layer to the water, the rate increasing with the difference between the concentrations of salt in the layer and in the adjacent water. If the concentration of salt in the water becomes equal to that in the emulsion layer no further diffusion of salt from the emulsion can be expected. From this the advantage to be gained by frequent changes is easily seen. Agitation during washing is very advantageous, since it displaces water heavily loaded with soluble salts from the emulsion surface and replaces it with fresh water. It can be assumed (Clerc) that washing has been sufficient when the concentration of soluble salts in the wash water is of the order of 0·01 per cent. For quick and efficient washing, eight changes, each lasting for 2 minutes with rocking, should prove satisfactory. Without rocking, six changes of 5 minutes each may be given. These figures assume the use of 5 oz. water per $3\frac{1}{2} \times 2\frac{1}{2}$ in. negative. With washing tanks employing continuous flow a proper circulation must be maintained with no blind spots. The "number of changes" system is, of course, often employed in tanks which have no continuous outflow, but are fitted with siphon devices to give periodic emptying.

HYPO ELIMINATORS

As indicated, water-washing properly carried out is no laborious undertaking. Despite this there is a demand for special methods by which the process may be made still quicker. In this connection, it is possible to carry out preliminary washing in potassium permanganate solutions until the pink colour is not discharged, after which only a short wash is required.

Various other hypo destroyers have been suggested, such as sodium hypochlorite, hydrogen peroxide, potassium persulphate, iodine, and potassium perborate, but it has also been suggested that most of the substances which can oxidize the hypo will also attack the silver image and may in addition form tetrathionate

and dithionate, which are probably as harmful and as difficult to get rid of as the hypo itself. Sodium hypochlorite has the additional disadvantage that the image afterwards contains silver chloride and may gradually develop irregularly coloured patches.

TESTING FOR RESIDUAL HYPO

This is best done by means of a solution containing potassium permanganate and sodium carbonate. Dissolve potassium permanganate 1 g. and sodium carbonate 2 g. in 1 litre of water. Add one drop of this solution to each of two vessels, one containing droppings from washing film and the other an equal quantity of the wash water taken direct from the tap. If the colour persists for the same time in both, then washing has been satisfactory.

EXHAUSTION OF FIXING BATHS

The life of a fixing bath depends upon a great number of factors, of which the number of films passing through is but one. For this reason it is not possible to state with any accuracy the number of films or plates which may safely be fixed in any given bath. The following figures may, however, be taken as a rough guide:—

4 No. 20 films	in 20 oz.
4 36-exposure miniature films ..	
32 $3\frac{1}{2} \times 2\frac{1}{2}$ in. plates	

DRYING

Initial surplus moisture can be mopped off with a clean, soft chamois leather, dipped in water and wrung dry. For satisfactory drying, care should be taken to avoid placing plates or films too close together, as this prevents effective access and circulation of air, with the result that the negatives dry slowly from the edges, the centre being last to dry. If removed to hasten the drying of the central damp patch, this latter dries with distinctly greater density. Negatives on flat or roll film are best dried by clipping on a line in such a manner that they cannot touch one another if blown about by draught.

Rapid drying by heat is not to be recommended except in properly designed drying cabinets; even if the films have been hardened, quick drying involves risk. Good circulation of clean air is much more expeditious than drying by heat.

Glass negatives and also films* may be quickly dried by immersion for two or three minutes in methylated spirit (not stronger than 80 per cent. at any rate for the final treatment), which should be used in ample quantity and frequently renewed, as it takes up water from each negative. These negatives will then dry within a few minutes in a brisk current of air.

* Some care must be exercised when treating films on acetate (safety) base in this way.

CHAPTER X

AFTER-TREATMENT OF NEGATIVES

The after-treatment of negatives, like control during development, originated in the days when it was necessary to produce negatives having a certain density range to suit the very limited number of printing materials in existence. Now that almost every printing material is available in a variety of contrasts there is less reason to keep the scale of the negative within such close bounds. In addition, there is Multigrade paper, which by variation in the colour of the printing light provides in itself a range of contrasts from very soft to ultra-contrasty, and is thus suitable for every type of negative. Even now, however, there are times when after-treatment is definitely advantageous, and in this chapter a number of methods are described which may be taken as reliable.

The various methods of increasing image density and contrast are known as intensification and those which are employed for lowering image density as reduction. According to the manner in which the reduction is brought about the contrast may be increased, reduced or kept constant.

PRINCIPLES OF INTENSIFICATION

The action of the intensifier is to convert the silver which forms the image into a compound which is more opaque or more highly coloured, except in the case of physical intensification, in which additional silver is deposited upon the image. In every process of intensification it is important that the negative should be thoroughly fixed and washed beforehand, and the dishes made chemically clean with a solution made by dissolving 2 oz. of potassium bichromate in 20 oz. water and adding 2 oz. of sulphuric acid. The acid must be added to the solution and not *vice versa*. The solution can be used repeatedly until it loses its effect. It is strongly corrosive and should not be allowed to come into contact with the hands.

Several methods of intensification depend upon the addition of mercury, or a compound of mercury, to the silver image.

Note.—Mercury salts are exceedingly poisonous and all solutions should be clearly labelled **Poison.**

The most important methods involving mercury salts are:—

(1) Mercuric Chloride Bleach followed by blackening with Ammonia.

(2) Mercuric Chloride Bleach followed by re-development.

(3) The Monckhoven process in which the darkening is brought about by silver cyanide.

(4) Mercuric iodide one-solution intensification.

(1) Mercuric chloride bleach, ammonia darkening. The thoroughly washed negative is immersed in:—

Mercuric chloride	200 gr.	or	12 g.
Ammonium chloride	200 gr.		12 g.
Water, up to	20 oz.		500 c.c.

The mercuric chloride (corrosive sublimate) is bought in heavy fibrous pieces which are difficult to dissolve in cold water. The above stock solution keeps indefinitely and can be used repeatedly until it becomes too slow in action.

The solution should be made to flow over the negative and the dish rocked until the image is bleached, that is, until no sign of the original black image can be seen when looking at the back of the negative. This will usually take less than a minute.

The negative must then be *thoroughly* washed, *e.g.*, for half an hour in running water. Mercury salts do not wash out of gelatin at all readily, and for the cleanest results in intensification it is a good plan, though not essential, to soak the bleached negative in two successive baths (5 minutes in each) of weak hydrochloric acid, *viz.*:—

Hydrochloric acid, pure..	3 dr.	or	10 c.c.
Water, up to	20 oz.		500 c.c.

It is then washed for 5 or 10 minutes in running water.

A weak solution of ammonia is then poured over the negative, *viz.*:

Ammonia, 0·880	20 drops	or	1 c.c.
Water, up to	1 oz.		30 c.c.

The solution should not be stronger than here given. The negative is kept in it with constant rocking until the image is a full brownish-black when examined from the back. It is then washed for 5 or 10 minutes.

The mercury-ammonia intensifier gives a large increase in density and contrast, and is specially suitable for flat over-exposed negatives, since the ammonia has a certain solvent action on the lower densities. This may result in some loss of detail but it has a beneficial though erratic effect on contrast. Negatives intensified with mercury and ammonia are, unfortunately, by no means permanent.

(2) Mercuric chloride bleach, blackening by re-development. This process is identical with that described above except that a non-staining developer such as metol-hydroquinone is used in place of the ammonia solution. It gives nearly as much intensification as mercury-ammonia, and the results are much more permanent. Moreover, the process can be repeated if very great intensification is required. The best of all re-developers, although it is scarcely ever used, is ferrous oxalate. This is perfectly stainless and gives an intensified image of silver and mercury which is as permanent as the original one. It is the only process of intensification which has been

proved to give this degree of permanence. In the event of over-intensification with mercury, a little or all of it may be removed by treatment with a weak solution of hypo—a few drops per ounce of plate-strength fixing bath.

(3) Monckhoven intensifier. This method is suitable only for excessively flat negatives; it gives too great an increase of contrast for those which are of good gradation but lacking in vigour. It differs from mercury-ammonia only in the darkening solution which is used, *viz.*:—

Potassium cyanide	130 gr.	or	7 g.
Silver nitrate	200 gr.		11 g.
Water, up to	20 oz.		500 c.c.

The cyanide (intense poison) and silver nitrate are dissolved in separate lots of water and the latter added gradually to the former, with constant stirring, until a permanent precipitate is just produced. The mixture is allowed to stand a short time and then filtered. If, after intensification, the negative is too dense it can be reduced with a 5 per cent. solution of hypo.

(4) Mercuric iodide intensifier. This intensifier has two very practical advantages, and although it yields only a moderate increase in density, this is sufficient in most cases. Negatives require washing for only a few minutes after fixing, and the degree of intensification is seen at each stage of the process. The intensifier is a mixture of mercuric iodide and sodium sulphite, which can be bought in powder or solution form or made up as follows:—

Sodium sulphite (cryst.)	4 oz.	or	100 g.
Mercuric iodide	90 gr.		5 g.
Water, up to	20 oz.		500 c.c.

The sulphite is dissolved first and the mercuric iodide then stirred in. The solution keeps well in the dark.

The negative steadily gains in opacity in this solution and is washed for a few minutes after the required stage has been reached. It is liable to turn yellow in time, but if placed for a few minutes in any non-staining developer the results are of satisfactory permanence.

Chromium intensifier. Intensification by means of bichromate hydrochloric acid bleach with subsequent re-development in pyrogallol was first suggested by Eder about 1880. Here the silver image is reinforced by the brown image formed by the developer oxidation products. Piper and Carnegie proved that the intensification was partly due also to the formation of a chromium compound and they found that there was a greater tendency to the formation of this compound if the bleach were made only slightly acid.

The negative is bleached in a mixture of potassium bichromate and hydrochloric acid, washed and re-developed. The less acid in

the solution the greater the degree of intensification, but the bleaching is inconveniently slow if the acid is greatly reduced.

The bleaching solution is made up from the two following stock solutions, both of which keep indefinitely:—

SOLUTION A

Potassium bichromate	1 oz.	or	25 g.
Water, up to	20 oz.		500 c.c.

SOLUTION B

Hydrochloric acid	2 oz.	or	50 c.c.
Water, up to	20 oz.		500 c.c.

For a medium degree of intensification, mix at the time of use: Solution A, 4 parts; Solution B, 1 part; water, 5 parts.

For a lesser degree, sufficient to give a touch of contrast, mix Solution A, 2 parts; Solution B, 2 parts; water, 1 part.

The bleaching solution is allowed to act until the negative bleaches to a buff colour through to the back. The negative is washed free from yellow stain, re-developed (by daylight or after exposure to daylight) with an amidol or metol-hydroquinone developer and then washed for a few minutes. The process can be repeated if required.

Uranium intensifier. This intensifier should be used only for the one purpose for which it is suitable, *viz.*, improvement of a thin, under-exposed negative, as the results are of limited permanence. Two stock solutions are required:—

SOLUTION A

Uranium nitrate	200 gr.	or	11 g.
Water, up to	20 oz.		500 c.c.

SOLUTION B

Potassium ferricyanide	200 gr.	or	11 g.
Water, up to	20 oz.		500 c.c.

The intensifier is prepared at the time of use by mixing Solution A, 4 parts; Solution B, 4 parts; glacial acetic acid, 1 part.

In this mixture the negative gradually becomes more opaque and brownish in colour. By stopping the action at an early stage, under-exposed shadow detail is strengthened without appreciable intensification of the heavier densities. The negative is then washed to remove the yellow stain. This should be done by several soakings in *still* water. Running water is liable to produce a patchy effect owing to the fact that the intensification is destroyed by the faintly alkaline salts present in many waters—a trace of acid in the washing water will prevent this. The intensification can be removed altogether with a weak solution of sodium carbonate and repeated (after thorough washing) if the point has been over-stepped

ILFORD ONE-SOLUTION INTENSIFIER

Mention must be made of a convenient intensifier marketed by Ilford Limited in the form of a powder which only requires to be dissolved in water. The solution, which is green in colour, is ready for immediate use, but will keep satisfactorily for several days. A precipitate will form during this time and this must be filtered away before using the bath. The negative must be thoroughly fixed and washed, and then placed in the intensifying solution and allowed to remain in it until sufficient density has been obtained. This usually occurs within a period of 5–6 minutes, but when greater intensification is required the time may be increased up to 10 minutes. Longer times should not be employed. It will be found that the density increases considerably as the negative dries. After intensification the negative should be well washed in running water (10 minutes) and then put up to dry.

REDUCTION

The process of reduction is concerned with the removal of some of the silver from the various parts of the image. Chemically it is not a process of reduction at all, but one of oxidation; the silver is converted into a soluble silver compound or into an insoluble compound which dissolves in some other constituent of the reducer.

The negative to be reduced will, in general, be too dense, but it may be too soft or too hard according to whether the density has resulted from over-exposure or over-development. Over-exposure, followed by over-development, gives a dense flat negative buried in fog. Correct gradation combined with inconveniently high density occurs when the degree of over-exposure has been within the latitude of the emulsion; that is to say, the scale of densities obtained is identical with that given by correct exposure, but it is heavier throughout. Needless to say, negatives cannot be sharply classified as coming in any one of the above three categories.

Reducers and contrast. Although there are no methods perfectly adapted for preserving, diminishing or increasing the contrast of a negative, much can be done by suitable choice of the reducer.

A reducer which removes density in amount proportional to the original density lowers the contrast of the negative "correctly." Its action, so to speak, is to undo the effect of development to some extent. A mixture of permanganate and persulphate is almost the only so-called *proportional reducer* which acts in this manner, and if it did not suffer from practical drawbacks, it would be ideal for negatives which require reduction only to correct for over-development. The Farmer reducer, if used very weak, serves the same purpose fairly well.

Most reducers, however, are largely *subtractive* in their action, *i.e.*, they remove silver to the same actual amount from every density in the negative. Hence, as a rule, the action on the shadow

detail is relatively much greater than on the highlights (see "Farmer's reducer" below). In theory a reducer of this kind does not affect the contrast of a negative except that the faintest densities may be entirely removed, and this may lead to blank harsh shadows which have a most objectionable effect in prints and enlargements.

On the other hand, so-called *super-proportional reducers* (*e.g.*, ammonium persulphate) act excessively on the heavy densities and thus reduce contrast very considerably. This is why the persulphate reducer is valuable for correcting the hardness (excessive density in highlights) of a negative which, as a whole, may not be inconveniently dense.

Farmer's reducer—also known as ferricyanide-hypo reducer—consists of a mixture of potassium ferricyanide and hypo. When a silver image is treated in this mixture, the ferricyanide converts it into silver ferrocyanide, actually a yellowish compound insoluble in water. The latter, however, is soluble in hypo solution and thus, in the use of Farmer's reducer, is dissolved as fast as it is formed. The two processes can be carried out separately by partly bleaching the negative in ferricyanide solution and transferring to a hypo bath. While this method has advantages in some cases, it is almost always preferable to use the reducer in its one-solution form, since the effect can be seen and the action stopped at any instant.

Although the Farmer reducer is usually made up in a somewhat careless manner—often by adding ferricyanide at random to any fixing bath that happens to be at hand—it should be used as directed below if stain is to be avoided and the most suitable effect obtained.

The ferricyanide is kept in stock 10 per cent. solution, *viz.*:—

Potassium ferricyanide	2 oz.	or	50 g.
Water (distilled)	20 oz.		500 c.c.

This keeps fairly well in the dark. The hypo solution is made by diluting the usual "plain" fixing bath (8 oz. of hypo in 20 oz. of water) with an equal bulk of water. Acid fixing bath should not be used, nor any hypo mixture sold as "fixing salts," which usually contain an acid substance and other ingredients.

The negative should be well washed after fixing. If it has been dried it should be allowed to soak in water for half an hour before reducing.

It is then placed for a minute or two in the diluted hypo solution, the latter poured back into a measure and a few drops of ferricyanide solution added. For a negative which is fairly clear in the shadows, dense in the highlights, and of excessive vigour, about 10 drops of ferricyanide per ounce of the hypo solution should be added. The mixture will be pale yellow. It is slow in action and does not quickly attack the faint deposits which form the detail in shadows. The dish must be kept rocked and the process carefully

watched, especially the effect on shadow detail. If the action is allowed to go too far the negative loses gradation in the shadows and will yield prints of a harsh appearance. If the required degree of reduction is not obtained in a little over 5 minutes it is well to throw the mixture away and make up fresh, since long immersion of the negative is liable to produce a yellow stain which usually nothing will remove.

For a negative which is dense all over from over-exposure and thus is of poor contrast, the reducer should be made up much stronger in ferricyanide (1 to 2 drams per ounce of hypo solution). It then attacks the shadow portions much more vigorously than the high-lights and clears off fog to a surprising extent. This kind of action is further enhanced by applying the reducer to the negative with cotton-wool soaked in the hypo-ferricyanide mixture and partly squeezed out. This method helps to confine the action to the surface of the emulsion, and with negatives of line subjects allows of the lines being reduced to almost glass clearness with relatively little reduction of density in the ground.

Persulphate reducer. Ammonium persulphate is a most valuable reducer for negatives which are hard and dense from under-exposure and forced development, owing to its relatively much greater action on the heavier densities. Unfortunately, its activity varies considerably in different samples. It is important to buy a reliable brand. The persulphate should be dissolved at the time of use in water made slightly acid with sulphuric acid, as follows:—

Ammonium persulphate.. ..	$\frac{1}{4}$ oz.	or	6 g.
Water, up to	10 oz.		250 c.c.

This solution should be slightly acid. If not, it should either be allowed to stand until it becomes so, or 1 or 2 drops of sulphuric acid may be added to it. It is important that the water should be free from dissolved chlorides.

The negative must be thoroughly washed free from hypo. The reducer is poured over it and the action carefully watched, since it becomes more rapid after some reduction has taken place. The dish must be constantly rocked. After a short time the solution becomes milky and, if sufficient reduction has not been obtained by then, should be thrown away and replaced by fresh, the negative being placed in clean water meanwhile. By working in this way brownish stains and patchy action will be avoided. For the same reason the surface of the negative should never be touched with the fingers whilst in the reducer, nor should a solution be used for two negatives in succession.

When reduction has gone nearly, but not quite, far enough, the reducer is poured off and the negative flooded with a 5 per cent. solution of sodium sulphite to stop further action of the persulphate. It is then well washed and dried.

Proportional reducer. Acts proportionately on the densities of the negative.

SOLUTION A

Potassium permanganate	2 gr.	or	0·12 g.
Sulphuric acid (conc.) ..	13 m.		0·75 c.c.
Water, up to	20 oz.		500 c.c.

SOLUTION B

Ammonium persulphate..	½ oz.	or	12·5 g.
Water, up to	20 oz.		500 c.c.

For use mix one part of A with three parts of B.

REMOVAL OF STAIN

Developer stain. A very effective method of removing the heaviest developer stain is by use of the bleaching solution worked out some years ago by Ilford Limited, *viz.*:—

Potassium permanganate	50 gr.	or	3 g.
Common salt	¼ oz.		6·5 g.
Acetic acid, glacial	1 oz.		25 c.c.
Water, up to	20 oz.		500 c.c.

This solution oxidises the stain to a soluble substance and at the same time converts the silver image into silver chloride. The negative is immersed in it for ten minutes with constant rocking, rinsed and soaked in a solution of potassium metabisulphite (1 oz. in 20 oz.) until the negative is white when viewed from the back. It is then re-developed fully with a non-staining developer such as M.-Q. or Amidol.

Owing to the very acid character of the bleach, it is well to harden the film first by immersion for a few minutes in a solution of chrome alum, 50 gr. (2·5 g.); water, 10 oz. (250 c.c.).

Silver stains. The brownish patchy stains which occur on negatives through moist contact with P.O.P. or other paper containing soluble silver salts require entirely different treatment. Such stain consists of silver in a finely divided state on the surface of the emulsion. Frequently it can be removed by rubbing the dry negative for a minute or two with an abrasive such as Frictol, or metal polish, and then leaving it to soak in a strong solution of hypo. If this is ineffective a short immersion in the iodine-cyanide mixture (as used for clearing bromide prints, see p. 274) will usually remove the stain completely. The mixture should be used 3 to 4 times weaker than given in the formula. Owing to its fineness, the silver stain is attacked and removed before the image is affected.

CHAPTER XI

FAULTS IN NEGATIVES

Never destroy a faulty negative until the cause of the fault has been ascertained. You will be wiser as the result of your investigation and may save yourself much trouble and annoyance in the course of further work.

It is, of course, impossible to mention *every* fault which may occur, but we propose to deal with as many as possible—usual and unusual. In order to facilitate identification, description of the appearance of the negative is given as a sub-heading, and beneath it are listed the various faults which may be the cause of this appearance (see index on pages 235-237). Many faulty negatives are illustrated, but it will be appreciated that it is impossible to reproduce on paper the true appearance of any transparency and, moreover, with faults such as over-exposure and light-scatter, which are likely to produce very dense negatives, the density has been reduced in our reproductions so that the other characteristics of the negatives may be seen. At the same time, the illustrations will generally be found to give a better understanding of the nature of a particular kind of fault than the most careful description, and for this reason frequent reference should be made to them.

In arriving at the cause of any particular fault, the first step should be to narrow down the field of investigation by reference to the index on pages 235–237. By following up the references to text and illustrations in the index, it should be possible to classify the fault as one of exposure or of development, and then, from the evidence available, it should be a simple matter to identify the cause. The majority of faults can occur in *all* types of material, but where any faults are peculiar to, or most likely to occur with, a particular type of material or camera this fact is mentioned.

The cause of faulty negatives is rarely traceable to the material. Reputable photographic materials are made with such scrupulous care, and subjected to such rigorous testing, that it is rare indeed for even a minor defect to escape the vigilance of the examiners.

Unsharp Negatives. Unsharpness is of several kinds. It may arise from the image being out of focus, due to misjudgment of distance, incorrect setting of the focussing scale, or to approaching nearer than ten feet from the subject when using a fixed focus camera. More rarely the unsharpness may be due to a faulty focussing scale, incorrect register of the film or plate, or to the components of the lens being misplaced. In the case of a miniature camera with coupled range-finder and focussing scale, unsharpness may

be due to the coupling being out of adjustment. This is unusual, but it may happen when the camera is dropped or knocked violently.

With reflex cameras and other cameras focussed by means of a ground-glass screen, unsharpness will result if the ground-glass screen is removed and replaced with the ground side away from the lens. Frequently, some part of the subject will be sharp, but not the part which ought to have been in best focus.

Occasionally, when a folding camera has been used, fuzzy unsharpness may be found to exist more at one side of the picture than at the other. The fault is due to the front of the camera having been bent slightly forward or backward, or to its having become loose on its runners through wear, with resulting backward sag.

If the fuzziness exists more in the centre of the picture than at the sides, then the fault may be due to the camera (if of the folding type) having been opened too quickly, and the film sucked forward out of the plane of focus by the partial vacuum so formed.

Another kind of unsharpness is caused by unsteady holding of the camera during exposure, resulting in several images of the subject being recorded, each shifted slightly from the others. A magnifier will usually show these separate outlines, which serve to distinguish this kind of fuzziness from that mentioned above, as does also the fact that camera-shake generally causes unsharpness of everything in the picture. This can be prevented by holding the camera very steady and *pressing* the shutter instead of *jerking* it. A "time" exposure with the camera held in the hand will result in unsharpness from this cause.

The beginner who uses a miniature camera, and very often, too, an experienced photographer who has just changed to a miniature camera, have trouble with camera-shake when using slow snapshot exposures—1/10th to 1/20th second. This is due to the fact that a degree of camera-shake which would pass unnoticed in a quarter-plate or $3\frac{1}{2} \times 2\frac{1}{2}$ in. negative, is a serious fault in a negative measuring only $1\frac{1}{2} \times 1$ in., which must subsequently be enlarged. Miniature camera photography calls, in fact, for greater care and precision throughout.

Sometimes the blur caused by camera-shake will be found to exist over only a part of the negative. This may be due to one of two causes. In the case of a miniature camera, or reflex camera fitted with a focal plane shutter, the shake may have occurred when the slit in the blind had already travelled across half the width of the film.

The alternative explanation, which is applicable to any type of camera, is that one hand of the photographer moved while the other remained still, thus one side of the camera moved more than the other—usually it is the hand which presses the shutter release which is the more likely to shake.

It should not be overlooked that camera-shake can occur when the camera is used on a tripod if there is any vibration due to wind, to a passing vehicle or to carelessness on the part of the photographer. If the tripod legs slip or slide, too, the same effect will be seen in the negative.

There is also another kind of unsharpness, which is really diffusion of a sharp image, and may be caused by dirt on the lens, or by the lens becoming clouded when brought from a cold atmosphere into a warm one. This produces a softness over the whole picture which is sometimes, in fact, quite pleasing.

An unsharpness somewhat similar to camera-shake is obtained, in the case of moving objects, if the shutter is too slow; the image of the moving object has time to move on the plate or film while the shutter is open. This occurs chiefly with objects crossing the line of sight and, of course, affects the moving part of the subject only.

This fault can be prevented in three ways:—

(*a*) By giving a faster shutter exposure and using a wider lens aperture.

(*b*) By swinging the camera carefully so that the image of the moving subject remains in the same place in the picture area, and the movement is imparted to the background. This helps to suggest speed and is a most effective trick.

(*c*) By standing near the line of approach of the subject.

There is no remedy for unsharpness of the negative, but it can often be covered to some extent by printing on a grained surface paper.

Thin Negatives. Insufficient density of the negative as a whole arises from under-exposure or under-development (or both). Some idea of the cause may be obtained by noticing the occurrence of detail and the density of the highlights (sky) relatively to the shadows. If there is detail everywhere, though faint in the shadows, and if the shadows are free from veil (almost clear when the negative is laid face down on white paper), the cause is under-development, *i.e.*, for too short a time, or in a solution which is cold or partly exhausted. The negative is weak (thin, rather than flat) and clear. The chromium or mercuric iodide intensifier will increase the density to give very much the same effect as though development had been continued for the proper time.

If the negative shows detail throughout, including the shadows, but is veiled all over (so that the picture appears to be buried in fog when the negative is laid face down on paper), the cause is over-exposure followed by under-development. Beginners make the mistake of stopping development when they see the picture "going

black." It is not easy to remedy an over-exposed and under-developed negative satisfactorily, but intensification will often make a marked improvement.

Unless the negative is excessively thin, it is worth while to reduce it slightly with ferricyanide-hypo before intensifying. This requires considerable care, but the negative can then be intensified with a better chance of success.

If the negative is thin only in the half-tones and shadows, which are badly lacking in detail, but of fair density in the sky or other highlight, the cause is under-exposure. The negative looks hard, owing to the highlight density, but the other parts are wretchedly flat. It is made worse by the usual intensifier, but is often improved sufficiently to yield passable prints by treatment with the uranium intensifier.

In the case of negatives which are weak or flat from under-development, satisfactory prints can frequently be obtained by using a contrasty paper such as Selo Contrast Vigorous, or for enlargements, Ilford Bromide Paper, Contrasty or Extra Contrasty.

Dense Negatives. Excessive density of negatives results from over-development, but the character of the negative varies very greatly according to whether the exposure has been reasonably correct, too much or too little. The means for improvement likewise differ in the respective cases.

In the case of negatives which have had reasonably correct exposure, over-development results in increased contrast. The heavier deposits grow more in density relatively to the faint deposits in the shadows. The negative looks "hard" and grainy. If this contrast is excessive, the range of densities will be too great to be rendered in the print, which will then be lacking in gradation of either the lightest tones or the darkest ones. The remedy is to reduce the negative with a solution which, so to speak, will undo the action of the developer. No reducer does this exactly, but Farmer's reducer is fairly satisfactory if used very weak. The permanganate-persulphate reducer, though nearer the ideal in action, is more troublesome to make up.

In the case of over-exposure, continued development will give a negative which is very dense and black all over, yet may be as perfect as one correctly exposed, except that much longer time is required for printing. This arises from the latitude of the emulsion. But if exposure has been grossly excessive, the negative, though dense, will be flat, that is, the total range of densities will be much less than that of the luminosities of the subject. In either case it is best to treat with Farmer's reducer until density is reduced to a degree suitable for printing. For negatives judged to be of satisfactory contrast, the reducer should be used weak; if the negative is thought to be flat, a stronger solution should be used. (It is a good plan to make certain by taking a print before reducing.) Then, if necessary, the negative

is brought to satisfactory contrast by intensifying with mercury and ammonia. Really extreme over-exposure may result in reversal of the negative to an imperfect positive.

Over-development of a negative which has been much under-exposed results in excessive density, chiefly in the highlight and heavier deposits, which become opaque and almost unprintable. The best reducer is ammonium persulphate, but it is often difficult to remedy a negative of this very hard or "chalky" character.

Fog—ranging from a thin uniform deposit (called "veil") which causes the negative to print flat, to a heavy one which obliterates the picture—may be due either to general action of light other than that from the lens, or to chemical action.

The condition of the edges of the film, or other portion protected from the action of light in the camera, provides a clue to the probable cause. If these, or parts of them, are practically free from fog, the cause must be sought among things which can possibly happen to the plate or film in the camera, whereas fog which covers every bit of the negative is probably due to action of light before or after exposure, or to chemical action.

Fog in the camera arises from gross over-exposure (*e.g.*, use of a shutter set by accident to "time" instead of "instantaneous"); from the scattering of light caused by a dusty or dirty lens or reflection of light from the bellows (slight veil); from a scattering of the light which often occurs when the camera is pointed directly against a strong light; or from leakage of light into the camera, in which case the fog often occurs as a band or streak, the position of which gives some indication of the point of leakage, such as a loose-fitting camera back.

Fog or veil over the whole surface may arise from some accidental exposure to white light, or to unsafe darkroom light (handling plates and films too close to the lamp). Fog may even occur from exposure of negatives to white light before they are completely fixed, especially if a plain (not acid) fixing bath is used. Apart from improper action of light, wrongly compounded developer or the contamination of developer with hypo may cause the defect. Materials which show persistent fog should be tried with freshly compounded developing solutions. Fog along the edges of roll film is caused by the spool becoming loose, and light penetrating between the spool paper and the metal flange of the spool. Such fog extends sometimes right across the width of the film.

Light fogging of miniature camera films while in the camera is unusual but the possibility of light leakage in the cassette should never be overlooked. If a cassette with a velvet-edged light lock has been used several times and the nap flattened, light is likely to leak in and fog the film at the beginning. Cassettes made of carton board must always be suspect if reloaded by the photographer.

As a rule nothing can be done to remove fog whatever its cause.

General Stain. Yellowish or brownish colour of negatives seldom occurs with modern emulsions and developers. When it does, the cause is almost always a stale or oxidized condition of the developer, due to the use of sulphite of poor quality, to a stock solution having been kept too long, to using a developer for too many films or plates, or to forcing a negative too long in the developer. It is most liable to occur with pyro, pyro-metol, and hydroquinone developers. When using hydroquinone developer, a yellow stain is liable to occur if negatives are not well rinsed between development and fixing. The acid fixing bath corrects the tendency to the occurrence of stain.

Developer stain can often be removed by the method given on page 221.

Dichroic Fog—a stain which appears green when looked at and reddish when looked through. It is caused by contamination of developer with hypo, ammonia, or other solvent of silver bromide or by keeping plates in an impure atmosphere or by the use of alkaline hypo or by one film lying upon another in the hypo bath. It is removed by very weak Farmer's reducer.

White (Clear) Spots. The two chief causes are air-bells clinging to the emulsion surface during development, and particles of dust on the emulsion surface during exposure and/or development. Spots of the two kinds may be distinguished by holding up the negative to the light and examining with a pocket magnifier. Spots from air-bells are all almost circular in shape. They generally arise from air-bubbles in the developer. Water drawn from pressure mains is usually highly aerated, and when used for diluting stock solutions is very liable to cause a crop of bubbles. For this reason as well as for chemical reasons it is most desirable to use boiled water for the preparation of photographic solutions.

Dust spots, under the magnifier, are seen to be of all kinds of shapes, much smaller than spots made by air-bells, and of sharp outline. The dust causing this trouble is almost always present in the camera before loading, and spool chambers, cassettes, plate holders, film-pack adapters, and the inside of the camera should regularly be wiped with a damp cloth. These spots are often caused by closing or opening cameras of the strut pattern very suddenly when an unexposed film is in place. Any dust on the inside of the bellows is forced on to the sensitive surface.

Clear spots on a negative may also be caused by dirty dishes or by impurities in tap water. Clear spots and "smudges" may be caused, too, by the adherence of scum to the surface of the emulsion

during development. This scum is found on the surface of tank developers which have been much used, and should be removed with a strip of paper before films or plates are inserted. The formation of scum and oxidizing of the developer are greatly reduced if a floating lid is used.

Clear spots arising from causes other than the above are very seldom met with. Developer which has become stale from age or use, or is contaminated with wax or grease, is liable to cause light spots of irregular shape. In tropical countries, similar spots may be formed by bacteria which have found the damp gelatin a suitable culture medium. In temperate climates, cases are occasionally met in which the gelatin coatings of negatives have been eaten into minute holes by insects.

Light spots of comet shape on a ground of heavy fog are also rare, and may be a puzzle until their cause is found. They arise from leakage of light from some point which causes rays to graze the emulsion surface. Particles of dust on the latter cast shadows which, in the negative, form the comet-like spots on the ground of fog.

Clear spots on negatives cannot be rectified otherwise than by physical retouching.

Dark Spots—caused by undissolved particles of the developing agent (amidol, hydroquinone, etc.) in the developing solution; settlement on the emulsion coating of particles of metol, amidol, etc., suspended in the air of the darkroom from previous weighings of the dry chemicals (spots produced by metol dust are very characteristic—they are clear with dark edges); dark, insoluble particles of oxidized developer formed in old or used developing solutions.

Particles of solid matter in tap water may also settle upon the gelatin emulsion and cause spots.

Yellow or Brownish Spots. The cause is air-bells still clinging to the emulsion surface in the fixing bath and thus obstructing the action of the hypo. If noticed soon after fixing, they can usually be removed by returning the negatives to the fixing bath, but since the air-bells will in all probability have been present in the developer the process of fixation will simply fix out the undeveloped silver bromide and leave clear spots.

Light Bands and Patches are usually less easy to diagnose than dark ones. Some of these defects are of very obscure origin. The following may be noted:—

A light or clear band across one end of the negative usually means omission to draw the slide of the plate-holder or film-pack adapter fully out or that the projecting baseboard of the camera is obscuring the field of view of the lens.

A clear patch on a roll film negative, with three straight edges and

one irregular edge, may be due to the sealing paper having been torn off and becoming lodged in the body of the camera. An irregular shaped patch may be caused by a small, loose fragment of such paper.

Band of lesser density along one side or end of the negative—fixed but unrinsed negative left projecting from the water in the washing tank. Patches of lighter density may also occur on film negatives left to fix with parts above the surface of the hypo bath.

Areas of lighter density may also be due to uneven flooding of the film with developer, the light areas having remained dry longer than the remainder. This is a common fault when only a very small quantity of developer is used.

Small, round light patches—finger tip markings—are produced if the emulsion is touched before development with slightly greasy or chemically contaminated finger tips. The finger print pattern usually provides a clue to the cause of this defect. Splashes of hypo on the sensitive material before development will cause clear patches or patches of lighter density.

If it is necessary to repack plates (*e.g.*, between exposure and development), the original wrapping papers should be used. Exposed plates should never be stacked face to back between exposure and development, but always face to face and preferably with the slip papers replaced.

A light patch surrounded by an edge of greater density is likely to be a drying mark caused by a drop of water remaining on the emulsion after the remainder was dry. Drying marks may also be caused on film negatives by drops of water remaining on the celluloid side. A blank, undefined area at one edge of the negative may be due to part of the picture being cut off by the photographer's finger over part of the lens. Blank areas at the corners of the negative are caused by the lens not covering fully: if only the top corners are affected the fault may be due to the use of excessive rising front. A fault of similar appearance may be caused by a badly fitting or unsuitable lens hood.

When only a part of the end negative of a roll film is developed and the image ends with a more or less defined edge, the cause is insufficient solution in a vertical developing tank.

Blank areas or areas of low density on a roll film may be due to two films having been in contact during development, one film preventing the solution from reaching the other.

Dark Bands and Patches. Almost always, this type of fog is due to leakage of light into the camera. If the fog has the appearance of a ray originating at one edge of the plate or film, the cause may be sought in a small point of leakage somewhere in the camera back.

In a roll film camera, looseness of the camera back may be responsible while, in the case of a plate camera, a leakage in the dark

slide or film-pack adapter, bad fitting of the slides or adapter, or worn condition of the velvet surfaced light traps, may cause the trouble.

A central circular patch of fog may be caused by accidental release of the shutter with the camera ("folding pocket" or miniature types) closed. Light penetration of the leaves of a diaphragm shutter, if these are of ebonite, by long exposure to intense light (more liable to occur on panchromatic films or plates, which are sensitive to the reddish light transmitted by thin ebonite) will cause a similar defect. A round or oval patch may be a "flare spot," more especially if the picture has been taken against the light. Light reflected from bright metal parts inside the camera or in the lens or shutter may cause similar trouble.

Lens flare is comparatively rare, but scattering of light and reflection of the shape of the lens diaphragm are seen fairly frequently when pictures have been taken against the light. Because of the greater number of reflecting surfaces which they incorporate, anastigmat lenses are more liable to produce this fault than single lenses.

A patch of fog of irregular shape may be caused by pouring developer on to the centre of a plate or by adding accelerator (alkali) to the developer while the plate is in the dish.

Splash markings of greater density may be caused by water or developer which has been splashed accidentally on to the sensitized material before development. Similar markings of rather less density may be caused by water splashing on to the dry negative.

Dark finger-print patterns occurring on the negative are caused by touching the sensitive material with developer-contaminated finger tips before development.

Dark or degraded edges of the negative are caused by storage of the sensitive material in a damp place. The fault is usually accompanied by some degradation over other parts of the negative.

Irregularly shaped streak marks of greater density extending from the end (or ends) of a roll film for from six to nine inches are due to the film being held by the hands during strip development by the see-saw method. Developer warmed by the fingers runs down the film each time one end is raised and produces greater density in the parts it touches. To avoid this, always hold the ends of the film in non-corroding clips. Dirty or corroded clips, however, are liable to cause markings similar to those just described. Defined dark markings on a plate or flat film negative may be caused by contamination from a dirty developing dish.

A peculiar kind of fog may very occasionally be found on a plate which has been used in a new wooden darkslide or has been in contact with the wooden surface of a drawer or bench. Frequently the wood grain is seen and the cause is chemically active substances in the wood. Nothing can be done to remove this fog from the

negative, but it can be prevented by repainting the inside of the dark slide "dead black." Paint containing turpentine must not be used, because this spirit is very liable to fog photographic emulsions.

Chemically active substances are also present in some printing inks and for this reason sensitized material should never be wrapped in printed paper. The ink used to print lettering and numbers on the duplex paper of roll films is made from substances which are inactive in this respect.

Yellowish or reddish patches, usually not occurring until some time (days or weeks) after the negative has been finished, are caused by incomplete fixation. In the case of films, they may be due to part of the negative floating above the surface of the fixing bath or to one film pressing on another. If the patch has a straight edge the latter cause is indicated.

Line Markings. Fine, clear lines running the length of a band of roll film are caused by friction of the emulsion surface against rough guide rollers or against dust or grit on the latter; they may also be caused by the guide rollers being jammed and failing to revolve as the film is wound across them.

Similar "telegraph wires" may occur along the length of a miniature camera film due to the film having been rolled or pulled too tightly, or to the velvet light trap of the cassette picking up grit which causes scratches as the film is drawn through the camera.

Irregular lines may be caused by the film being allowed to touch the working bench—almost any form of friction on the sensitive surface is liable to cause such a mark. A tiny "arrowhead" mark may be caused by the film being allowed to "kink."

Dark line round an outline where (in the subject) dark objects come against a light background. This effect occurs in tank development when the solution is allowed to remain without movement for the whole period of development. Solution in contact with a heavy deposit becomes exhausted, whilst that on an adjoining light deposit (largely unexhausted) runs over to the former, adding further density all along the edge.

So-called "streamer" lines, *i.e.*, bands of extra density running from the image of a narrow, dark object such as a chimney, a flagstaff, etc. The cause is similar to that of the edge line just mentioned, *viz.*, downward diffusion of largely unexhausted solution in stagnant tank development. The same type of fault can occur in the case of miniature camera films developed in an amateur tank, but in this case the streamers will run across the *width* of the film and are likely to be most intense adjacent to the perforations. It will not occur unless the agitation of the developer is insufficient. The spool bearing the film must be rotated at frequent intervals throughout the course of development.

Tangle markings, *i.e.*, a tangle of dark lines, sometimes covering the entire negative. The cause is a pinhole in the body or between-lens shutter of the camera. On carrying the latter about in bright sunlight, the pinhole forms an image of the sun on the emulsion surface, and the position of this image changes continuously as the position of the camera changes. The result is a continuous line, running here and there, according to the directions in which the camera was pointed. When lighting is diffused, the indication of a pinhole, in the bellows, will be small, dark patches on the negative, with heavy centres and undefined edges. A pinhole in the blind of a focal plane shutter will cause a line of slightly greater density across the negative.

Many short "hair-line" marks all over roll film negatives—these are called "cinch marks," and are caused by pulling the spool very tight after removing it from the camera and before sealing. These marks rarely occur on Selo Films, which have a surface coating specially designed to prevent abrasion.

Halation, *i.e.*, spread of density from the image of bright parts of the subject on to surrounding portions, obliterating detail in the latter. Common examples are the blur of fog round the windows in interiors and from the image of the sky on to that of tree branches. It is prevented by the use of backed films or plates (all Ilford and Selo Films are anti-halo backed and all Ilford Plates can be supplied with special soluble backing).

Irradiation may also occur in such cases. This is due to reflection of the image of a bright part of the subject *within* the sensitive emulsion and, of course, backing is powerless to prevent it. Negatives showing halation or irradiation are difficult to remedy, but can be improved in many cases by rubbing down the affected parts with a fine abrasive preparation such as Frictol, or by bleaching as for chromium intensification, washing thoroughly and developing for a short time only in a strong developer. The negative is then re-fixed and washed.

Positive instead of Negative. At times, the image (when finished in the usual way) will appear as a positive instead of a negative; usually a greatly fogged positive. Frequently, part only of the subject is positive and the remainder negative. The reversal is generally caused by "forcing" an under-exposed plate or film by protracted development in an unsafe darkroom light. A printing action takes place through the negative first developed on to the underlying emulsion, the resulting positive then gathering density in excess of that of the original negative image. The defect is very seldom met with, but cases sometimes occur in which one or two negatives on a spool of film are perfect, whilst the others are reversed, the exposure to the darkroom light having been greater in the part of the spool affected.

Reticulation. A fine irregular grain over the whole negative, but most pronounced in the heavier densities. It arises from a physical change in the gelatin caused by sudden swelling on transference from a cold to a warm solution, or by sudden contraction when transferred from a warm to a cold solution and will sometimes occur during intensification with mercury and ammonia. For prevention, the mercury solution should be acid, and the ammonia solution not stronger than prescribed.

Frilling and Blisters. These defects are manifestations of poor adhesion of emulsion to the base. Frilling usually occurs at the edges whereas blisters may be found at any point on the surface of the negative. Neither trouble is likely to be met with except perhaps when processing is carried out under the worst tropical conditions and when the various solutions are used at widely different temperatures. Frilling may, however, be caused by transference of negatives from a strongly alkaline to a strongly acid bath, and may also result if negatives are held by the edges with warm fingers.

Blisters can be largely removed by pricking with a needle when the emulsion is half dried. Frilling can be corrected to some extent by replacing the loosened emulsion carefully so that it will dry in position.

Mottle. This may be caused by age deterioration of the sensitive material, by deterioration caused by chemical fumes, or by exposure to the air as in the case of a roll film left in a camera for a period of months. Another form of mottle may be caused by the growth of bacteria or fungus in the gelatin in hot and humid climates: stagnant developer is the cause of yet another type of mottle.

A mottle which is more or less defined all over the picture will arise if a backed plate is inserted into the dark slide the wrong way round, so that the light forming the image has to pass through the backing before reaching the emulsion—the picture will also be reversed left to right. Similar mottling will occur if a backed plate is left face downwards on the darkroom bench long enough for the darkroom lamp to fog the emulsion.

Dull Image. When the dullness of the image is due to insufficient density of the negative and to a certain amount of veil which extends over the margins, the cause is probably exhausted or contaminated developer. The presence of stain on the negative confirms this. This dullness also may be due to incorrect compounding of the developer. The weakness of the developer is responsible for the weakness of image, and forcing or contamination of the solution is liable to produce the chemical fog and stain. Such a negative can be improved by slight reduction followed by chromium intensification.

Dullness of the image of a negative of good density may be due to inadequate fixation. Undissolved silver salts remain in the

negative and obscure the clear parts. Refixing and washing is usually successful.

Dullness of the image may also be due to dichroic fog, which is dealt with on page 227, or to veiling of the picture by slight general light fog, to scatter from the lens or to chemical fog.

Do not overlook the possibility of dullness being due simply to over-exposure or to under-development, which are explained on pages 224 and 225. The subject, too, may have been poorly and flatly lit, when only a dull reproduction can be expected.

OTHER FAULTS

The reasons for some photographic failures are so obvious that they need hardly be described. For example, the blurring and mingling of the image which occurs when the emulsion melts is unmistakable and can be attributed only to the use of hot solutions or to drying at too high a temperature.

If the picture slants within the picture space and this fault is found to occur frequently, it is likely that the view-finder of the camera is bent or, if of the swivelling type, may not have been fully turned into position.

When pictures overlap on a roll film the fault is under- or over-winding. This may be met with in $2\frac{1}{4}$-inch square cameras using $3\frac{1}{4} \times 2\frac{1}{4}$ roll film if the winding indicator is not very precise.

Torn and/or cockled edges of a roll film are caused by misalignment in the camera. Often this fault is accompanied by edge fog, due to light entering where the spool paper was torn. The misalignment may be due to a bent or broken spool chamber spring, or to one or both of the small guide rollers being bent or moved out of the true position owing to wear of the bearing ends.

One must not be dismayed by the foregoing formidable list of the failures which may occur in negative making. The aim has been to put into small compass descriptions of most of the defects which may arise, not excepting many which are of most uncommon occurrence and all the more puzzling on that account.

The information in this section, backed up by your own knowledge and experience, will enable you to identify almost every negative fault which you may produce. It is possible, however, that at some time you will be faced with a problem which needs expert investigation; in this case if you write to Ilford Limited every effort will be made to help you.

INDEX TO PHOTOGRAPHIC FAULTS

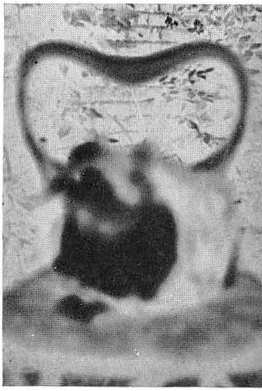
The index on pages 235-237 is included to assist you in the speedy identification of negative faults. It must, however, be used in conjunction with the general evidence in your possession—type of material, type of camera used, etc. It attempts to sum up, very briefly, the information given in the foregoing pages, and reference should be made to these pages, and to the following illustrations.

Appearance of Negative	Fault	Information	Illustration
		Page	Page
Unsharpness			
Fuzzy definition	Out of focus .	223	238
Blurred all over . .	Movement of camera .	223	240
Blurred image of part of subject	Movement of subject .	224	238
Too dense all over			
Flat and much shadow detail	Over-exposure .	225	239
Contrasty	Over-development	225	239
Too thin all over			
Lacking shadow detail .	Under-exposure .	224	239
With shadow detail but lacking contrast . .	Under-development .	225	239
Dark Markings			
Dark areas with images of lens diaphragm . .	Light scatter	226	240
Black "blobs" with images of lens diaphragm . .	Lens flare . .	230	
Black "splashes" . .	Light leak in camera .	226, 229	241
"Splashes" of greater density	Water or developer splashes before or after development	230	242
Black finger marks .	Developer-contaminated finger tips . .	230	
Black edges (roll film)	Edge fog	226	241
Black circle in centre .	Accidental exposure with folding camera closed .	230	240
Dark or degraded edges .	Damp storage	230	241
Uneven dark streaks .	Dirty dishes .	230	241
Black streaks, usually from one corner . . .	Light leaks in holder, adapter or camera back	226, 229	243
Fine black lines . . .	Abrasion marks .		243
Dark streamers from light parts of negative extending on to dark parts . .	Tank development—insufficient agitation . .	231	244
Black spots . .	Chemical dust	228	244
Dark ribbon-like tangle	Sun tracks	232	243

Appearance of Negative	Fault	Information	Illustration
		Page	Page
Tiny dark ↓ shaped mark, accompanied by dimpling of film negative . .	Kink mark .	231	
Very short, rather faint hair lines close together all over roll film negative .	Cinch marks . . .	232	
Dark streamer marks, intense at end of roll film and fading off down length of the film . . .	Chemical fog caused by dirty film clips or holding film with hot fingers during development . . .	230	
Wood grain markings .	Fog from wooden dark slide	230	245
Printed characters superimposed on image . .	Newsprint fog .	231	245
Light Markings			
Clear areas or areas of lower density . . .	Hypo contamination .	229	242
Sharply defined blank area .	Paper in camera .	229	245
Clear finger marks .	Greasy or contaminated fingers	229	242
Sharply defined irregular areas of lesser density .	Uneven covering with developer	229	246
Irregular clear spots . .	Developer scum . . .	228	246
Picture fades into transparency at corners . .	Lens not covering . .	229	249
Clear scrape marks—emulsion removed . .	Abrasion by finger nail or by other negatives . .		247
Emulsion removed or loosened at edges . . .	Frilling	233	247
Large spot of lighter density with greater density at edges	Drying mark . . .	229	248
Line of lighter density .	Loose thread on blind of focal plane shutter . .		249
Irregular lines of lighter and greater density . .	Too vigorous brushing before development . . .		246
Irregular shaped small clear spots	Dust on material during exposure . . .	227	250
Round spot either clear or of lighter density . .	Air-bells during development	227	248
Undefined clear area at one edge of negative . .	Hand partly covering lens .	229	249
Clear curved margin at one of the longer edges of roll film negative taken with bellows-type camera .	Cut-off due to rapid opening of camera . . .		250

Appearance of Negative	Fault	Information Page	Illustration Page
Mottle			
Dappled marking which can be seen also by reflected light	Old material	233	
Defined mottle without physical marking of surface	Exposure or fog through backing	233	252
Defined pattern with physical marking of surface .	Reticulation . . .	233	250
Irregular streaky mottle .	Insufficient agitation during development . . .		251
Dull Image			
Insufficient density with some veil over shadows .	Exhausted developer .	233	251
Brownish appearance of back	Inadequate fixation .	233	251
Reddish stain when looked through—greenish stain when looked at . .	Dichroic fog	227	
Obscuration of the picture to a greater or lesser extent.	Light fog or chemical fog	226	
Distortion			
Converging upright lines .	Camera tilt		252
Exaggerated perspective .	Short focus lens used too near subject		253
Miscellaneous Faults			
Dark halo around highlights	Halation or irradiation	232	254
Two images on same negative	Double exposure		253
Blurring and mixing of the image accompanied by irregularities in emulsion surface	Melting of emulsion . .	234	254
Positive or partial positive instead of negative (normal density) . . .	Reversal due to fogging by unsafe darkroom lamp during development .	232	255
Positive or partial positive instead of negative (extreme density) . .	Reversal caused by excessive over-exposure . .		255
Picture slanting on negative	Bent view-finder . .	234	255
Two images over part of the negative . . .	Over- or under-winding of film spool . . .	234	
Torn or cockled edges (roll film)	Misalignment in camera .	234	

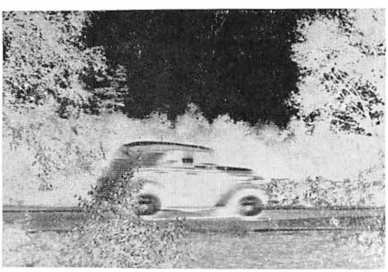
IMAGE OUT OF FOCUS



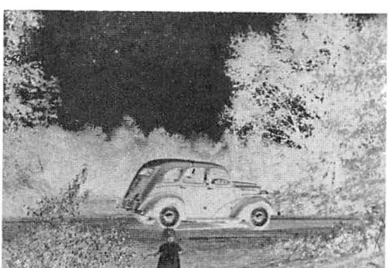
1 When a box camera or other "fixed focus" camera is used the subject must not be nearer than 10 feet from the camera, or the picture will have this appearance.

2 If a portrait attachment is fitted to a "fixed focus" camera it is then possible to approach to 3 feet from the subject to obtain a sharp image.

MOVEMENT OF SUBJECT



3 The shutter exposure must be brief enough to "arrest" the image on any moving parts of the picture area. In this case the car was travelling at 20 m.p.h. and was photographed in 1/25th second.



4 The car was also travelling at 20 m.p.h. when this picture was taken, but a shutter exposure of 1/100th second has given a reasonably sharp image.

5 Caused in this case by *under-exposure.* There is little shadow detail in the negative and only the highlights are recorded.

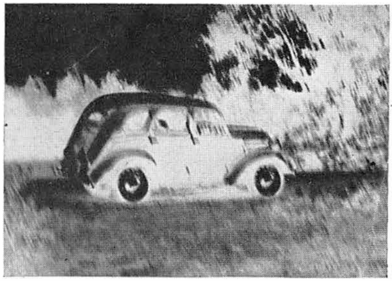
6 Caused in this case by *under-development.* It is characteristic that shadow detail is present, but that the highlights lack adequate density.

DENSE NEGATIVE

7 The denseness here is caused by *over-exposure*. There is abundance of shadow detail, but the very dense negative is flat.

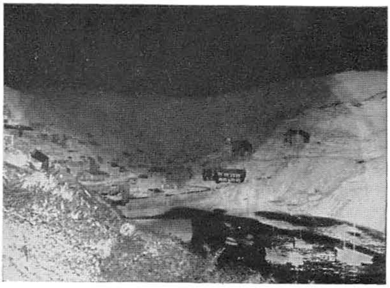
8 In this case the negative is *over-developed*, and although it is much denser than the normal the outstanding characteristic is extreme contrast.

CAMERA MOVEMENT



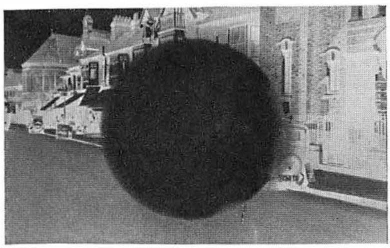
9 This is undoubtedly the most common photographic fault, and is caused by the camera being held unsteadily at the moment of exposure. (The car in this picture was stationary.)

LIGHT-FOGGED AREAS



10 Light-fogged areas like this are caused by scattering of the light by reflection from the glass-air surfaces of the lens when the camera is pointed directly against strong light.

ACCIDENTAL EXPOSURE



11 This circular black patch is characteristic of accidental exposure with a folding camera, with the bellows closed. The accidental exposure may not be noticed, and the next picture taken will show this defect.

LIGHT LEAK IN CAMERA

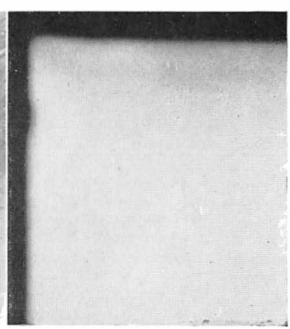
EDGE FOG

12 Rays of light may enter a pinhole in the bellows of a folding camera and produce characteristic areas of light fog like this. The defect, however, may appear only occasionally, many negatives taken in the same camera being unblemished.

13 Due to loose winding of a roll film. Light has penetrated between the edges of the protecting paper and the metal end of the spool.

DIRTY DISH MARKINGS

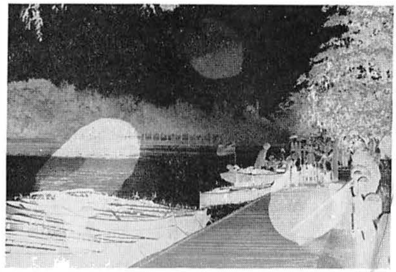
DAMP STORAGE



14 These are caused by a form of contamination from residual chemical impurities remaining in the bottom of a dish, or having been absorbed into the material of which the dish is made.

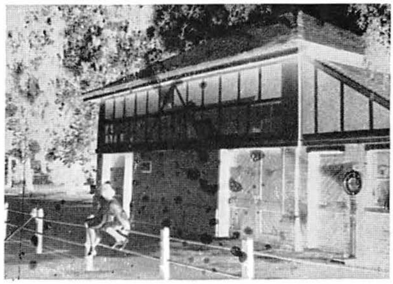
15 Damp storage may result in fogging around the edges of the material when developed and is often accompanied by veil or mottle all over the negative.

HYPO CONTAMINATION



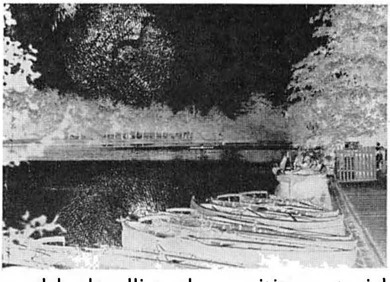
16 Splashes of hypo have fallen on the surface of the material before development and removed some of the sensitive silver salts.

WATER SPLASHES



17 Marks caused by water splashes on the sensitive emulsion before development.

FINGER MARKS



18 These are caused by handling the sensitive material before development with greasy or chemically contaminated fingers.

ABRASION MARKS

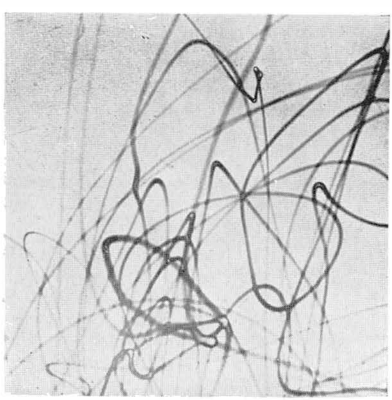
19 If sensitized material is scratched or scraped, a dark line or mark will appear on development. In some cases a little of the emulsion may actually be removed, and this may result in a line of lesser density across a dark part of the negative. Ilford Plates and Papers and Selo Films are specially protected against this trouble, and abrasion must be very severe for marks to result.

LOOSE CAMERA BACK

20 Marks like this are due to light fog caused by *loose fitting of the camera back, film-pack adapter or darkslide.*

Similar markings may be caused when replacing the sheath of a film-pack adapter or darkslide by inserting one corner first.

SUN TRACKS



21 This tangle of ribbon-like fog markings is caused by the image of the sun formed by a pin-hole in the camera body or bellows. This image moves about as the camera is carried.

CHEMICAL DUST

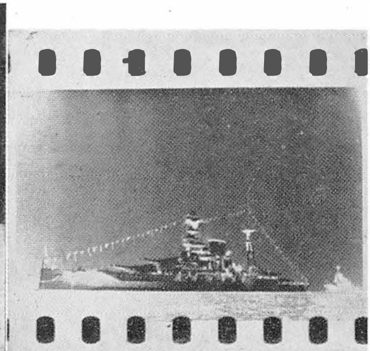
22 Chemical dust which may be floating in the atmosphere may settle on the sensitive surface of the material and produce spots like these on development. Never prepare your developing solutions in the darkroom.

WATER SPLASHES

23 Water splashes on the negative after drying.

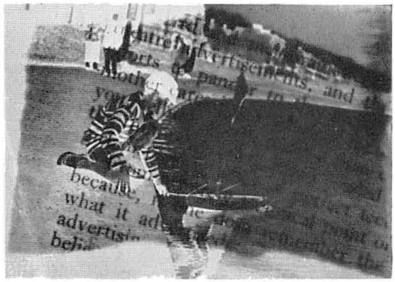
DEVELOPMENT STREAMER

24 A dark streamer results from insufficient agitation of the solution during development by the tank method. Under certain conditions a light streamer may also result from this cause.



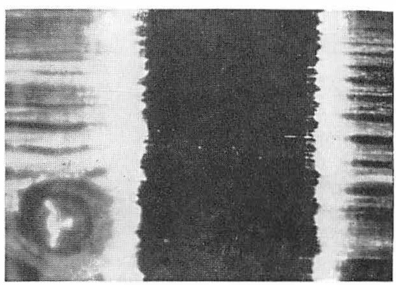
25 This is how the same fault appears on miniature camera negatives which are held horizontally in the amateur type developing tank.

NEWSPRINT FOG



26 Many printing inks are chemically active and can cause this characteristic fogging. Therefore, plates and films should never be wrapped in newspaper. Special inactive printing inks have to be used for the numbering and printing of the duplex paper protecting roll films.

FOG FROM WOOD



27 Caused by chemical action from the wood of a new wooden dark slide.

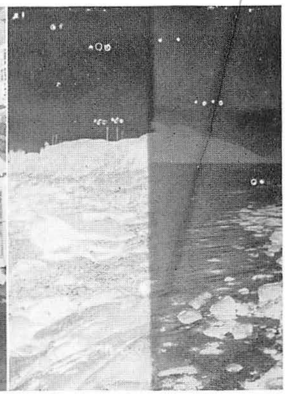
LOOSE PAPER MASKING

28 Due to the presence of paper inside the camera. Loose roll film sealing tabs or plate separating strips are the most frequent causes of this trouble.

UNEVEN DEVELOPMENT

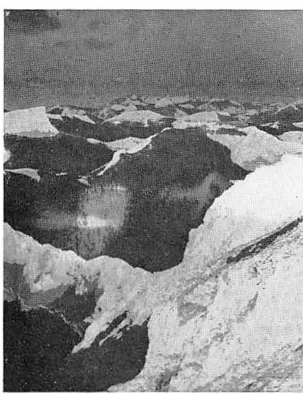
29 These areas of lighter density are characteristic of the use of insufficient developer. The material is not fully covered by the solution at once, and some parts receive more development than others.

SCUM



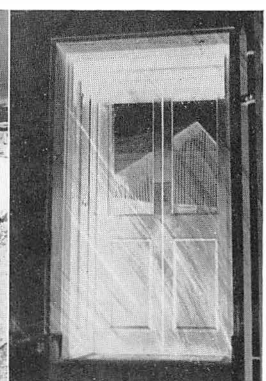
30 Scum on the surface of the developer may cling to the surface of the emulsion in places and prevent the action of the developer. The illustration also shows light fog caused by a defective darkslide.

CONTACT DURING DEVELOPMENT



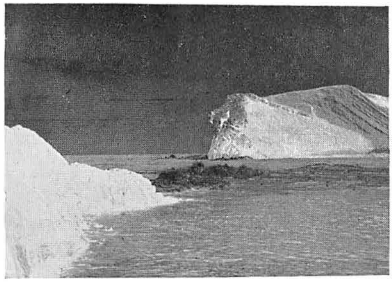
31 If one film remains in contact with another or with the side of the tank during tank development, an area of the film is likely to receive less development than the remainder, so that a clear patch or an area of lesser density may be created.

BRUSH MARKS



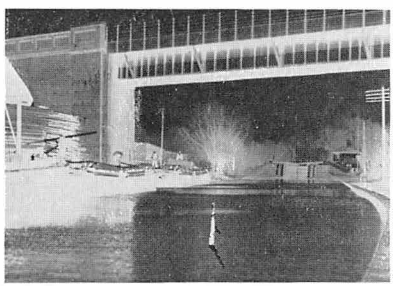
32 Brush marks caused by too vigorous use of the dusting brush on a plate before exposure or before development.

ABRASION MARKS



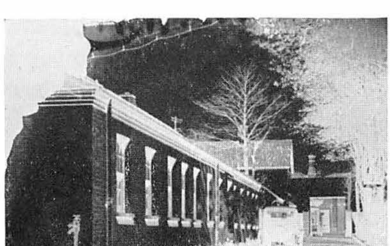
33 Abrasion marks may be caused on roll film or miniature camera film when tension of the film across the guide rollers is too great, or when there may be friction of the sensitive surface with part of the camera body or cassette, or with grit on the velvet light trap of a cassette. Slight abrasion will result in a dark line; deep abrasion may scratch the emulsion away and result in a clear line.

ABRASION DURING WASHING



34 An area of the gelatin emulsion is removed by scraping with a finger nail or the edge of another film or plate.

FRILLING

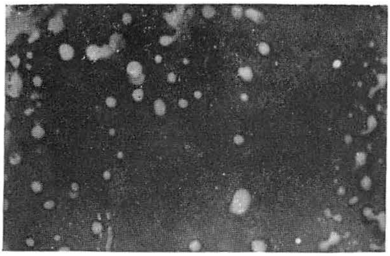


35 This is caused by the edges of the emulsion becoming loosened from the support, owing to careless handling in warm weather; to the use of hot solution, or to washing in a strong current of water. The trouble is almost exclusively confined to plates.

AIR-BELL MARKS

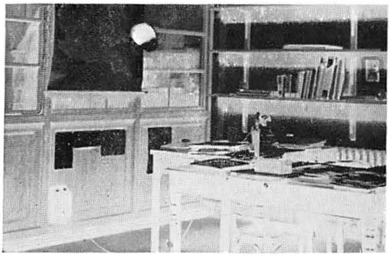
36 Tap water is often highly aerated, and air-bells may form on the surface of the sensitive material, thus preventing the developer from reaching it at those points.

AIR-BELLS MAGNIFIED



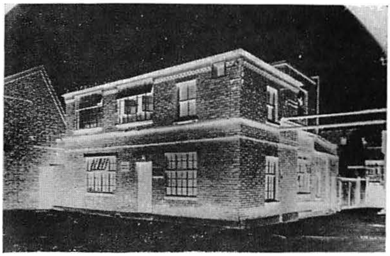
37 This is what air-bell marks look like when viewed through a magnifier.

DRYING MARKS



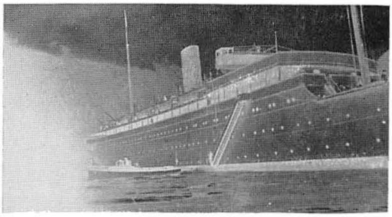
38 These may occur when the negative is taken directly from the washing water and dried by heat. Isolated drops of water keep small areas of the emulsion wet for a time, after the rest of the material is dry, and uneven contraction of the gelatin will result in such marks. They may be avoided by careful swabbing of the emulsion surface when the material is removed from the washing water.

CUT-OFF



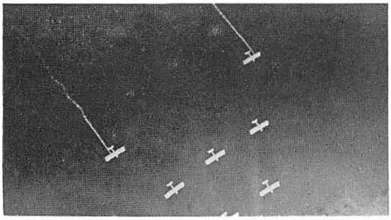
39 This is due to the lens not fully covering the area of the sensitive material, and is caused by the use of extreme rising front movement (cut-off at top corners), or by the use of a lens of insufficient covering power (cut-off at all four corners).

CUT-OFF



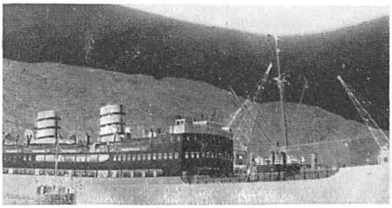
40 Due to the hand being held partly over the lens during exposure.

LOOSE THREAD ON FOCAL PLANE



41 *Loose thread on a focal plane shutter.* This may trail across the sensitive material, causing a line to receive less exposure than the remainder. A light line results (between the leading aeroplanes). Conversely a pin-hole in the shutter blind causes a dark line.

BELLOWS VACUUM

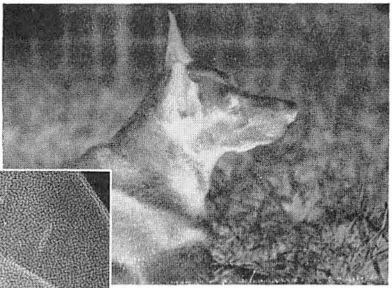


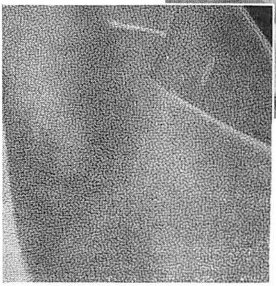
42 If a folding roll film camera is erected with a jerk a partial vacuum may be formed inside, causing the side of the bellows to cave in. This may be unnoticed at the time, and part of the picture is consequently cut off.

DUST

43 Dust on the sensitive material during exposure prevents light action, and results in clear spots on the negative.

RETICULATION





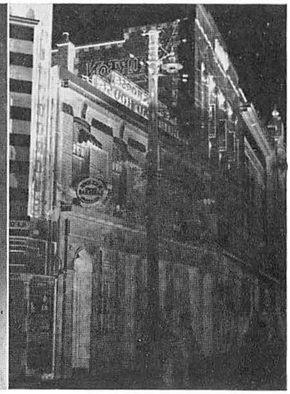
44 This occurs when the negative is removed from a very warm solution and placed directly into a cold one. The gelatin emulsion which has expanded is suddenly contracted. This sudden contraction is uneven, and produces a crinkled surface all over the negative.

45 This is the appearance of reticulation when the negative is examined with a magnifier.

STALE OR EXHAUSTED DEVELOPER

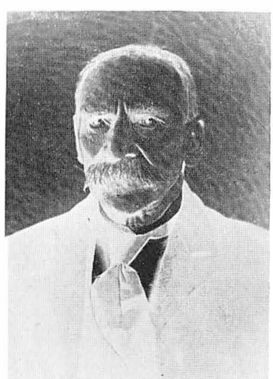
46 The developing action is too weak to give adequate density to the highlights and also likely to cause a deposit over the shadows by chemical fog.

INADEQUATE FIXATION



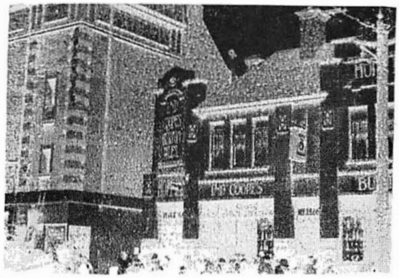
47 Inadequate fixation is characterized by a brownish appearance of the back of the negative.

IRREGULAR DENSITY



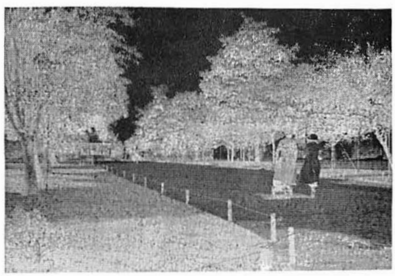
48 Irregular density such as is seen here is the result of the developer being insufficiently mixed; to insufficient agitation of the solution during development, or to a combination of both causes.

EXPOSURE THROUGH BACKING



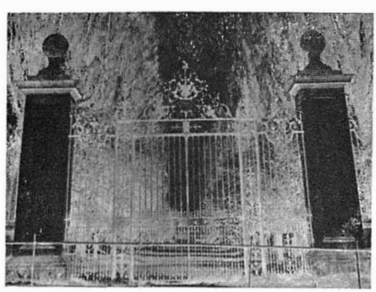
49 Due to loading a plate in the dark slide incorrectly with the backed surface facing outward.

FOGGING THROUGH BACKING



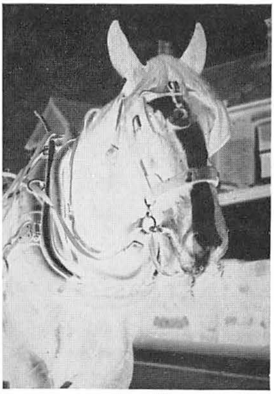
50 Caused by action of an unsafe darkroom lamp, when a backed plate is exposed to it through the backing. May be distinguished from exposure through the backing by the veil over the shadows.

CAMERA TILT



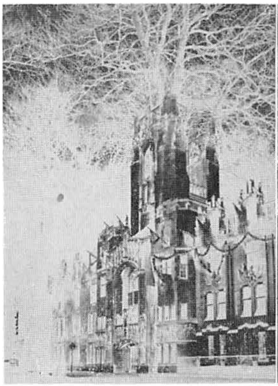
51 When the camera is tilted in order to include the whole of a high subject, distortion like this will result—it can be avoided by setting the camera quite level and using the rising front movement. The importance of this fault is often exaggerated.

FORESHORTENING



52 This exaggeration of perspective is caused by the use of a camera with a short focus lens very near to the subject. It could be avoided by using a more distant viewpoint; a correspondingly smaller image is obtained if the same lens is used, but an image of the same size can be obtained if a lens of longer focal length is used.

DOUBLE EXPOSURE



53

PARTIAL DOUBLE EXPOSURE

54 Due to over-winding or under-winding a roll film or miniature camera film, and caused by carelessness in winding or possibly to inaccuracy of the winding device.

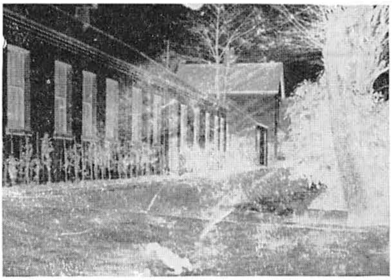
HALATION

55 This is caused by rays of strong light passing right through the film or plate, and being reflected from the back surface of the support. The reflected image exceeds the boundaries of the true image, and forms a halo of density around it.

MELTING

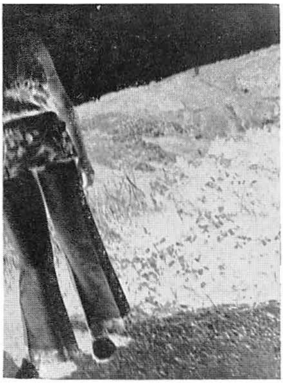
56 The sad fate of a wedding group negative dried by the use of excessive heat.

MELTING



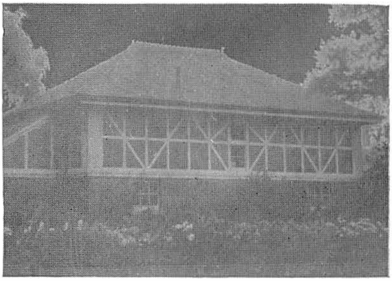
57 Melting due to using the hot water tap by mistake.

UNTRUTHFUL VIEW-FINDER



58 Tilted picture caused by bent view-finder or inaccurate location of a swivelling finder.

REVERSAL



59 Caused by an unsafe darkroom lamp. A faint negative image is developed before fogging starts, and this image is then "printed" by the unsafe light on to still sensitive silver salts beneath it. Thus the "negative" is partly negative and partly positive.

REVERSAL

60 Reversal like this is caused by extreme over-exposure, and is only found in an exceedingly dense negative. This subject received 600 times the correct exposure.

CHAPTER XII

PREPARATION OF NEGATIVES FOR PRINTING

Hand After-treatment. Various methods may be used for improving negatives in ways which are beyond the scope of the intensifiers and reducers described in Chapter X. These comprise retouching the film side with pencil or knife, hand-work on front or back of the negative, spotting, and blocking-out. Formerly, these processes entered much more largely than now into the making of perfect photographs. The improvements in plates and films within the past few years, especially in colour-sensitivity, have removed the occasion for much of the labour previously spent before a negative was considered suitable for printing. In particular, the use of panchromatic plates and films for portraiture has largely dispensed with the retouching of portrait negatives, so often destructive of likeness and modelling. Nevertheless, specially difficult subjects or conditions at the time of exposure frequently produce negatives which can be immensely improved by one or other of these hand methods.

Removing Halation or Irradiation. Density which has spread from a highlight to adjoining shadow parts of the negative may be removed by rubbing hard with fine wash-leather stretched tight over the tip of the finger and moistened with best methylated spirit, or, better still, pure spirits of wine. On a perfectly flat surface, *e.g.*, plate glass, lay two or three thicknesses of blotting paper and on them the negative to be rubbed down. The negative must be perfectly dry and the rubbing should not be confined exactly to the part to be reduced, but may extend somewhat beyond this area without loss of detail. The process is slow; by using a mild abrasive such as Frictol on the leather, it may be hastened considerably, but must then be carried out with somewhat greater care.

Hand-work on the back of the Negative. A great deal may be done to modify the negative by hand-work on the back. Parts may be held back in printing or caused to give a darker tone in the print, and a variety of methods may be employed for both glass and film negatives. In many cases the thickness of the glass negative is an advantage; the outline of any hand-work is softened in the print and is far less liable to betray its presence by a hard line. If need be, a film negative may be bound to a glass plate with a gummed strip and treated like glass.

For holding back parts of fair size a little tube water-colour such as gamboge or Payne's grey is mixed with good liquid gum and a very little of the mixture brushed over the area, or, better still, a

little beyond it. The coating is then made perfectly even with a fitch-hair dabber or the finger-tip, and when dry is "trimmed" to the required outline with a sharp scraper blade.

A method of more general scope is to coat the entire back of the negative with matt varnish and to work on this with pencil, with chalk applied with a stump, or with tube water-colours (gamboge or carmine) applied with a brush. Matt varnish for this purpose is made by the Vanguard Co., both plain (colourless) and yellow and pink. The two latter are for use when a considerable obstruction of light is required. It is flowed on to the back of the negative as in cold varnishing (see page 261) and dries in a few minutes. The matt coating may then be scraped away over parts which are too dense, or over all parts except those which are too thin. In addition the matt coating may be worked on with soft pencils (BB) or Conté crayon, or (for larger areas) with black stumping chalk, applied with a leather stump or finger tip, a little of it being first spread on a small piece of chamois leather so as to avoid putting on too much at once.

A method which is much more suitable for finer work, because the coating is perfectly transparent, is carried out by flowing the back of the negative with a preparation made by the Vanguard Co. under the name of Billdup. Film negatives may be dipped in it and drained. The coating dries hard in a few minutes and will then take a good deal of pencil work with a No. 4 B. Further work can be put on with stumping graphite powder applied with a dry camel-hair brush. Negatives worked up in this manner should be printed or enlarged through fine ground-glass; any hand-work shows more than when done on matt varnish.

Spotting. Clear spots are removed by filling in with neutral tube water-colour. A red sable brush (No. 1 or No. 2) is the best for the purpose. It is first placed in water, and as much of the water as possible removed by drawing it against the side of the cup or glass. A little of the colour is squeezed on to the palette and a little of this thinned out with water. The brush, semi-dry, should be pointed by revolving on the palette and a minute quantity of the thin colour picked up on its tip. The negative (on a retouching desk) is now touched with the tip of the brush at the required spot, holding the brush almost at right-angles to the surface. A tiny spot becomes filled in with one application of the brush. Larger spots will require several touches, each being allowed to dry before applying the next. The spot may then require to be stippled over. The minimum of colour and semi-dryness of the brush are the chief secrets of neat spotting. Transparent lines, such as scratches, are best filled in with pencil as in orthodox retouching. It is most important that the brushes used for this purpose should be of good quality, capable of presenting a good point for use. This applies emphatically to all

brushes for photographic work; the best obtainable will pay for their extra cost in satisfactory use.

Blocking-out. A perfectly white background in the print is required chiefly in the case of industrial subjects, such as machinery, furniture and pottery photographed for catalogue illustrations. With these classes of subject there is no objection to a sharp outline, and the blocking-out is done on the emulsion side with "Photopake" applied with a sable brush of about No. 4 size. The negative is supported on a retouching desk, and a band of opaque about one-eighth of an inch in width drawn round the outline. A print from the negative is of great assistance if the outline is at all intricate. When there are straight edges, a draughtsman's pen charged with the opaque may be used against a transparent xylonite set square. The edging of "Photopake" is then extended by applying the material with a larger brush or by adding black paper on the back of the negative.

For subjects of difficult outline, *e.g.*, hair in portraits and foliage in landscapes, the foregoing method gives too hard a line. With such subjects the outline is worked in with soft pencil on the emulsion side, this pencil band being then extended with "Photopake." Or the negative may be blocked out on the back with the transparent medium sold as "Actinone," which, acting as a filter, prevents the passage of the blue light to which printing papers are sensitive. When hard, the coating can be scraped or serrated with knife or needle to soften the outline. Here again the glass negative possesses an advantage because of its thickness.

Retouching is usually understood to be the working-up of a negative with pencil or knife on the emulsion side. As applied to portraits it is an art in itself, which can be learnt only by practice and calls for a knowledge of facial anatomy and for an artistic sense of the value of lights and shadows in the tonal composition of a portrait. The latter in turn requires familiarity with the lightings used in a portrait studio. Hence we must be content to indicate briefly the lines along which the reader should practise. For proficiency some lessons are almost essential, although much may be learnt from a text-book such as "Retouching," by J. Spencer Adamson.

The negative must be supported on a desk of Z shape, that is to say, a base to which the negative carrier is hinged. This latter, in turn, carries a screen for the head. The desk should be of ample size. The inclined part, or negative carrier, should be about 30 × 30 in., hinged to a baseboard about 30 × 24 in., on which it is adjustable by side struts at an angle of 60° to the base, so that one's forearm rests comfortably and firmly on the negative stage when one sits upright close up to the front of the base. The negative, or rather the portion of it which is being retouched, should be comfortably below the level of the eyes. The retoucher should be able to sit

back comfortably on a chair which supports the spine firmly; a posture in which the body leans forward soon proves fatiguing and should be avoided. The top limb of the Z consists of a board about 30 × 16 in. and supports a dark cloth by which light from the sides is excluded.

The inclined stage may be fitted with a rotating carrier or turntable, allowing the negative to be positioned exactly as required and provided with carriers to take the various sizes. In practice many professional workers view the negative through a hole of about $2\frac{1}{2}$ in. diameter cut in the negative stage, further cutting down this aperture, if necessary, by a piece of opaque paper, with a smaller hole in it, held over the negative.

When working by daylight, the table on which the desk stands is arranged close to a window with the blind drawn down to within about 18 in. of the bottom. The light is reflected through the negative by white blotting paper laid on the baseboard. A mirror is not advisable except for negatives of exceptional density. By artificial light the illumination should be diffused, *e.g.*, by reflection from blotting paper, or by use of a frosted electric bulb. Additional comfort for the eyes may be obtained by using a faint blue glass fitted on the under side of the hole in the negative stage. Glass of this kind, and also Crookes glass, can be obtained from Messrs. James Hetley & Co., Soho Square, London.

Owing to the smoothness of the surfacc, very little pencil work can be put on negatives. Those made with matt emulsion have an advantage in this respect, but in general the surface requires to be given a tooth by rubbing with "medium," which actually is a solution of resin, and leaves a rough coating which "takes" pencil well. The medium supplied by the Autotype Co. is one of several satisfactory makes. A very little medium is applied to the perfectly dry negative with a soft rag or the finger tip and rubbed round and round so as to leave a smooth patch without any trace of stickiness.

Pencils for retouching are made in degrees of hardness ranging from No. 1 (softest) to No. 6 (hardest) as marked by some makers. In other brands, *e.g.*, Koh-i-noor, the letters B (black) and H (hard) denote the range. For general use No. 2 (or B) and No. 3 (or H.B.) are the most suitable. These softer leads save time, but less skilled workers will do better with harder leads for a time. They are best obtained as loose leads, which are used in a holder and are sharpened to the finest point by drawing over fine emery or glass paper, at the same time rotating the holder between thumb and second finger. The softer the lead the greater the amount which can be put on the negative, and when skill has been acquired such leads enhance the scope and speed of the work.

The pencil is held lightly between the thumb and first and second fingers, as in writing, at an angle to the negative so that the lead wears more or less on the side of the point. The kind of "stroke" or

"touch" may be cross-hatching, zigzag lines, round-and-round scribble, minute figures of eight, etc. Whatever it is, it should be done gradually, with the aim of matching the depth and texture of the surrounding density as closely as possible and of obtaining the desired result with the least amount of work. The most skilful portrait retouchers will not, however, keep to one particular stroke but will vary the touch according to the subject and the part of the face. One guiding principle is that the pencil should follow the lines of the features; another is to modify the fineness of the work according to the smoothness or coarseness of the sitter's complexion, although it must be admitted that in many cases sitters are not satisfied unless the marks of age are almost entirely removed.

Retouching with Knife. In professional retouching considerable use is made of a knife for reducing the density of highlights, thus getting improved gradation in these parts, and also for modifying outlines, even to the extent of altering the shape of the nose or chin, or making the entire figure more slender. Any knifing of a negative is done before the pencil is used, and the negative must be absolutely dry. Actually knifing consists in scraping off the gelatin with a very sharp blade such as an "etching" knife sold for the purpose, or a safety-razor blade. The knife is held almost perpendicular to the surface of the negative and drawn along with very light pressure (parallel with itself) so that several strokes are required to produce a barely perceptible effect. Parts of any considerable size are more satisfactorily treated by rubbing down with the "Frictol" abrasive paste already mentioned, applying it with a soft leather stump. As a rule a negative which has been knifed to any great extent requires to be worked up in pencil in order to supply tone or detail in place of that which has been removed.

Varnishing. Years ago professional photographers and also many amateurs varnished every negative as a matter of course, to safeguard it against the silver stains liable to be produced on it if the print-out papers then in universal use or the negative were damp. The general adoption of development papers has made this practice unnecessary, except where a negative is likely to have long and continuous use; in such cases varnishing is advisable for several reasons. It protects the silver image from wear and from the tarnish or "bloom" liable to occur in course of time through the action of traces of sulphur compounds in the air. It serves to fix retouching and also allows of retouching being carried out (on the film of varnish) to a much greater degree than can be done on the gelatin surface. Also, in tropical countries, it is a protection against moist heat and insect pests.

Plate negative varnishes are of two kinds, hot and cold, so named according to their manner of use. The hot varnish, consisting of a solution of shellac and other resins in spirit, is preferred by

professionals as the basis of further retouching. In applying it as described below, the negative must be perfectly dry and slightly warm to the touch. The varnish should be flowed over the plate and the excess drained off; the varnish sets almost immediately and the plate can then be rapidly dried over a gas ring or hot plate. Unless these points are observed the varnish may dry matt instead of clear and transparent. On the other hand, an advantage of the hot or spirit varnish is that the coating is dry and hard as soon as the negative has cooled.

For amateur use, a cold varnish consisting of celluloid dissolved in amyl acetate or other solvent is much to be preferred. The coating, however, should be left for an hour or two to become perfectly dry and hard. To apply the varnish, first dry the negative thoroughly, *e.g.*, before a gas fire, and leave it to become absolutely cold. Now hold the negative level on the outspread finger tips of the left hand, placing the ball of the thumb on the near left-hand corner, and pour enough varnish on the middle to form a pool about one-third the area of the plate. Let the varnish spread about equally in all directions and then tilt the plate very slightly so that the varnish runs towards and nearly covers the right-hand far corner. Next, cause it to flow in the same manner to the left-hand far corner and thence to the left-hand near corner, where the plate is held by the thumb. When this corner is not quite covered by the varnish, place the right-hand near corner in the neck of the varnish bottle and let the excess of varnish run back, meanwhile rocking the negative to and fro as long as there are any drainings. Finally, place the negative on a rack or stand it on edge to dry and harden.

Note. Negatives on roll, pack or flat film should not be varnished with the ordinary spirit (hot) negative varnish nor with the solution of celluloid just described. For such negatives the following formula is advised:—

Dammar Varnish

Dammar	1 oz.	or	100 g.
*Benzol 90 per cent. ..	10 oz.		1000 c.c.

Filter before use.

*This is Benzene, not Benzoline, and it must be 90 per cent.

CHAPTER XIII

DEVELOPMENT PAPERS

The sensitive printing papers now almost exclusively used are of the development type in which an invisible image is formed by exposure, and rendered visible by development. The three chief types, Gaslight, Bromide, and Chlorobromide, differ in speed and in other respects, but in each case the sensitive material is a suspension of silver salts in gelatin. In each case, the papers are made in a wide variety of tints and surfaces and emulsion contrasts. Two recent introductions which require special mention are Plastika and Multigrade. The first is a paper having a characteristic curve with a long straight line; the second is a versatile printing paper whose effective contrast can be changed at will. These papers will be described at greater length at the end of the present chapter.

PACKING AND STORAGE

Ilford Development Papers are packed in packets for amateur use, in boxes for professionals, and in continuous rolls for machine and commercial printers. Material which is to be sent to tropical climates is specially packed. As with all photographic materials, storage conditions must be satisfactory if the products are to retain their good qualities. Damp and noxious fumes must be avoided at all costs, and the storage room should be kept at an even temperature and should, if possible, be quite separate from the workrooms. Above all, remember that materials must not be stored in close proximity to rooms in which toning by sulphide or hypo-alum is carried out.

GRADATION

Grades of Contrast. As shown in Chapter III, the contrast of a negative is largely controlled by the time for which the plate or film is developed. In the making of prints, in which the silver deposit is something to be looked *at* and not through, the case is different. The contrast of prints from a given negative, provided exposure is correct, is determined almost entirely by the character of the printing paper, and for the purpose of obtaining satisfactory prints from negatives of different degrees of contrast, bromide and gaslight papers are made in various grades of contrast.

If various development papers are tested by giving progressively increasing exposures to parts of a strip of the paper it is found that the time of exposure required to yield the deepest black that the paper will give, as compared with the time required to produce a just perceptible tint of silver deposit, varies considerably with different papers. Approximately, these relative times are:—

	For Tint	For Deepest Black
Soft paper ..	1	40–70
Normal paper	1	25–30
Vigorous paper	1	10

These ratios (1:40, 1:25, etc.), represent the exposure ranges of the papers, and it will be clear that when making the average type of print, *viz.*, one including almost white tones and also maximum blacks, a negative which passes 30 times as much light through the thinnest parts (shadows) as through the densest (highlights) requires a paper of 1:30 range for correct rendering of its tones.

If the exposure range of the paper is shorter, say 1:10, and the paper is exposed for the tint in the highlights, those densities in the negative which pass 10 to 30 times as much light as the densest part will all be recorded as maximum black on the paper, yielding a hard print without gradation of tones in the shadows.

On the other hand, if the range is longer, *e.g.*, 1:50, and if, again, exposure is made for the highlights, light of 30 times intensity and less passed by the thinner parts does not suffice to give the maximum black of image, but only a grey, with the result that the print is flat. If longer exposure is given so as to get maximum black in the shadows, the lighter tones and highlights will be too dark; the print will still be flat though darker as a whole.

This somewhat rough and ready way of showing the relation which is necessary between the printing paper and the negative, for satisfactory rendering of the tones in the latter, will make it clear that a flat negative requires a short-range or contrasty (vigorous) paper, that a hard negative requires a long-range or soft paper, and that if two negatives of the same subject but of different degrees of contrast are printed on papers of scale suitable to each, the prints will be practically identical.

It will be understood, therefore, that a paper sold as "soft" does not necessarily give soft prints from a vigorous negative; it gives *softer* prints than would be obtained from the negative on a normal or medium grade of paper, but if the grade of paper is suitably chosen for the negative, the prints on "soft" paper will be fully equal in vigour to those obtained on a paper of shorter scale from a negative adapted to it. *Vice versa*, a contrasty or extra-contrasty (short-scale) grade of paper is for obtaining prints of normal vigour from flat, thin negatives. While these vigorous or contrasty grades are exceedingly useful for negatives of this kind, it is a mistake to aim at the kind of negative specially suited to this grade. For the finest photographic quality in prints, *viz.*, full range of tones from deep black to white, the aim should be to make negatives suitable for the longer-scale (normal) papers—in other words, negatives correctly exposed and developed to a fair degree of contrast.

A DESCRIPTION OF THE SURFACES OF ILFORD PAPERS

Ilford papers are available in a wide variety of surfaces which may be briefly classified and described as follows:—

No.

1 **Glossy**
A highly glossy smooth surface with a fine mauve-white base.

5 **Special Smooth Matt**
A perfectly smooth matt surface with a fine mauve-white base.

22 **Natural Grain Smooth**
A perfectly smooth dead matt surface with a pure white tint base. Suitable for colouring.

72 **Cream Smooth Natural Grain**
A similar surface to Natural Grain Smooth but with a cream tint base.

26 **Velvet**
A semi-matt surface but possessing an even grain, producing a velvety appearance.

32 **Rough Natural Grain**
A rough dead matt natural surface with a white-tint base.

6 **Eggshell**
A smooth surface with a trace of sheen with a mauve-white tint base.

56 **Cream Eggshell**
A similar surface to Eggshell but with a warm cream-tint base.

11 **Smooth Lustre**
A smooth natural surface with sheen, giving a lustre effect, with a pure white-tint base.

71 **Cream Fine Grain Lustre**
A similar surface to Fine Grain Lustre with a cream-tint base.

31 **Grained Lustre**
A heavy grained surface with lustre effect on a white-tint base.

33 **Rough Lustre**
A natural rough grain surface with lustre effect on a toned white-tint base, suitable for broad effects.

83 **Cream Rough Lustre**
A similar surface to Rough Lustre but with a cream-tint base.

91 **Cream Extra Rough Lustre**
An extra rough grain surface with lustre effect on a cream-tint base, for very broad effects.

27 **Silika**
A fine texture and delicate sheen resembling the frosty sparkle of fused silica ware.

77 **Cream Silika**
With similar characteristics to Silika, but on a cream base of the palest shade.

TYPES OF DEVELOPMENT PAPERS

GASLIGHT (CONTACT) PAPERS. The name "Gaslight" for this type of paper is intended to denote a material of sensitivity such that a source of illumination of the kind found in an ordinary living room can be used for exposure, while development can safely be carried out in the same room at a reasonable distance from the light. There is thus no need for darkroom or safelight. Development is a simple operation, which is usually complete in about half a minute, and with a paper of this type, quite a large number of prints can be produced in a very short time. The present tendency is to replace the term "Gaslight" by "Contact" to denote that the paper in question is of a speed suitable for contact printing. The brand name of Ilford Contact Paper is Selo, and the paper is available in a number of contrasts and surfaces. Selo Paper particularly recommends itself to amateurs, as the image colour is a pleasing blue-black, and the latitude in exposure and development is very considerable.

Gaslight papers are often referred to as chloride papers, because silver chloride is the chief silver salt, although other silver salts may be present in small quantities. In a similar way, the principal silver salt in bromide papers is silver bromide, but silver chloride and iodide may also be present in small quantities.

BROMIDE PAPER is the fastest type of development paper. Its speed, which is of the order of one hundred times that of gaslight paper, makes it the most suitable for making enlargements, and for the rapid production of prints by contact. It must be handled and processed by yellow or orange light, and this necessitates the provision of a room from which all daylight can be excluded—the illumination being provided by a properly designed darkroom lamp, screened with Ilford S. Safelight No. 902.

Bromide papers give prints of a fine black colour by direct development but, because of the popularity of this type of paper for professional and commercial work, many processes have been worked out for subsequent toning of the finished print, so as to facilitate the production of warm black, sepia and other coloured images. Ilford Bromide Papers are available on single and double weight bases, and in contrasts and surfaces for all purposes and effects. Bromide papers should always be developed right out, *i.e.*, for from $1\frac{1}{2}$–2 minutes in Ilford ID–20 at the recommended strength.

CHLOROBROMIDE PAPERS. A third important group of papers comprises the chlorobromides, which differ widely among themselves. In these, silver bromide and chloride are both present in important quantities. Some chlorobromide papers are only a little slower than bromide paper, others are much slower. Most of them are designed to give warm-toned images, and for this reason are favoured for studio and exhibition work.

Clorona, the Ilford Chlorobromide paper designed to give warm toned prints by direct development, is about 1/20th the speed of bromide paper. Clorona is made in a number of surfaces, of which one—Rayon—yields prints of quite remarkable richness because of the transparency of the shadows which are broken into a series of tiny regular dots. Clorona should be handled and processed by the light transmitted by the Ilford S. Safelight No. 902.

Developed in an ordinary M.Q. developer it gives a brownish black with exceptional richness in the shadows. Processed in a developer of low energy, it can give any one of a series of tones, ranging from orange through reds to brown-reds, browns and sepias to brown-blacks. Every print goes right through this sequence of tones, so that in an M.Q. developer of normal activity, red or brown-red prints would have to be removed at an early stage. In practice, when it is desired to get such tones, the activity of the developer is reduced by dilution and the addition of bromide, and the development time may even be longer than that required to give normal blacks with a normal developer.

From the foregoing, it is obvious that to get just the right depth of tone, combined with just the right image colour, careful adjustment of exposure and development is essential. It is to be noted also, that the very warm tones dry darker, so that visual judgment in the darkroom light is difficult. It is therefore essential to work systematically, to use the developer formula recommended and to follow instructions exactly. On the other hand, if it is not of much importance whether the image is a warm brown or a cold sepia, Clorona is extraordinarily easy to work, since enormous errors in exposure simply lead to changes of colour in the print. Full details are given in the booklet *Ilford Bromide, Clorona, and Plastika Papers.* One final word: warm-toned prints being only partially developed are much softer than normal prints, the warm image colour also reduces effective contrast, and so such prints should be made only from plucky negatives.

THE PROCESSING OF GASLIGHT AND BROMIDE PAPERS

Gaslight prints should be developed for a very short time (30 sec. to 1 minute) in an energetic developer. With Selo Paper it is possible to vary development time to compensate for errors in exposure. To get the best blue-black colour, the developer should contain only a very little potassium bromide. At high temperatures, however, the bromide content must be considerably increased. The Selo M.Q. Developer is particularly suitable and is available in tins and packets.

For bromide paper, a less concentrated developer is required—the Selo M.Q. formula may be used at half the strength recommended for gaslight paper, or the ID–20 formula specially recommended for

bromide paper should be used. An alternative formula for those who do not care to use M.Q. is ID–22 where Amidol is the reducing agent. Development time for bromide paper should be between 1½ and 2 minutes at 65°F. (18°C.)

For Clorona, as already indicated, the development time and the composition of the developer will vary according to the tone desired. The processing of Clorona Paper is separately described on page 282.

GENERAL INSTRUCTIONS FOR DEVELOPMENT PAPERS

The exposed print, bromide or gaslight, is immersed in the developer by sliding it face upwards under the solution. Development is a straightforward operation, but the print must be kept on the move and properly covered with solution. Several prints can be developed at one time in the same dish, provided there is sufficient depth of developer and that the prints are turned over repeatedly. The busy trade printer will find it convenient to develop prints in pairs, back to back, "feeding" them into the solution at regular intervals, keeping the pairs in sequence and removing them in order when fully developed. The action of carefully turning over the prints from bottom to top in a drawing movement provides an opportunity for dislodging any air-bells which may have formed on the surfaces.

For bromide prints the time of development must not be curtailed, otherwise they will not have the necessary quality and good colour; if a print reaches full depth before the expiry of full development time, it is a sign of over-exposure.

There are certain conditions under which development may have to be somewhat prolonged, *e.g.* (*a*) temperature of the developer too low; (*b*) use of a partially exhausted or too diluted developer; or (*c*) developer containing too much potassium bromide.

DEVELOPERS FOR GASLIGHT (CONTACT) PAPER

ID–36. SELO M.Q. DEVELOPER

Metol	56 gr.	or	3 g.
Sodium sulphite (cryst.)	4 oz.		100 g.
Hydroquinone	½ oz.		12·5 g.
Sodium carbonate (cryst.)	7½ oz.		187·5 g.
Potassium bromide ..	32 gr.		15 g.
Water, up to	80 oz.		2000 c.c.

A slightly different formula ID–29, designed for use with Gaslight Lantern Plates, is equally suitable:

ID–29. Metol-Hydroquinone Developer

Metol	15 gr.	or	0·75 g.
Sodium sulphite (cryst.) ..	1 oz.		25 g.
Hydroquinone	60 gr.		3 g.
Sodium carbonate (cryst.) ..	$1\frac{1}{2}$ oz.		40 g.
Potassium bromide, 10 per cent. solution (pot. brom. 1 oz., water to 10 oz.)	1 dr.		3 c.c.
Water, up to	20 oz.		500 c.c.

A suitable Amidol formula is ID–30—a modification of the formula ID–22 for bromide prints.

ID–30. Amidol Developer

Sodium sulphite (cryst.) ..	1 oz.	or	25 g.
Amidol	60 gr.		3 g.
Potassium bromide (10 per cent. solution)	20 m.		1 c.c.
Water, up to	20 oz.		500 c.c.

DEVELOPERS FOR BROMIDE PAPER

The Selo M.Q. Developer ID–36 may be used at half gaslight strength but the recommended developer is ID–20:

ID–20. Metol-Hydroquinone

Metol	15 gr.	or	0·75 g.
Sodium sulphite (cryst.) ..	1 oz.		25 g.
Hydroquinone	60 gr.		3 g.
Sodium carbonate (cryst.) ..	$1\frac{1}{2}$ oz.		40 g.
Potassium bromide	20 gr.		1 g.
Water, up to	20 oz.		500 c.c.

For use—dilute with an equal volume of water.

The alternative Amidol developer is ID–22:

ID–22. Amidol

Sodium sulphite (cryst.) ..	1 oz.	or	25 g.
Amidol	60 gr.		3 g.
Potassium bromide (10 per cent. solution)	80 m.		4 c.c.
Water, up to	20 oz.		500 c.c.

Development with the above developers should be complete in about two minutes.

After development the prints are quickly rinsed in clean water and transferred to the acid fixing bath. It is of the greatest importance that they should be turned over and over, after having been placed in this bath. Failure to do this may result in yellow stain. Some workers find it convenient to use an acid bath to stop development (as for negative materials). This bath may be of 5 per cent. acetic acid or $2\frac{1}{2}$ per cent. potassium metabisulphite, and it should

be discarded and renewed before there is any danger of its acidity having been completely destroyed by developer carried over with the prints.

FIXING BATHS

Prints *may* be fixed in a simple solution of hypo, but except in the case of printing out papers and bromoil paper, this course is not advised. An acid fixing bath, *i.e.*, a solution of hypo containing potassium metabisulphite or acetic acid, is very much to be preferred. Such a bath reduces the danger of staining to the minimum. Where processing temperatures are unavoidably high, as in tropical countries, it is advisable to use a hardener in the fixing bath, and this procedure has advantages even in this country when prints are to be hot glazed. Ilford papers are rendered sufficiently robust in manufacture to withstand hot glazing, except in exceptional circumstances, but there is no possible objection to the use of the hardening bath, and the extra precaution is well worth while. For all these fixing baths, suitable formulæ are given below.

ACID FIXING BATH

Hypo	4 oz.	or	100 g.
Potassium metabisulphite	½ oz.		12·5 g.
Water, up to	20 oz.		500 c.c.

Allow ten minutes for thorough fixation. Use fresh solution for each batch of prints.

ACID HARDENING AND FIXING BATH

Hypo	1 lb.	or	400 g.
Stock hardening solution ..	10 oz.		250 c.c.
Water, up to	80 oz.		2000 c.c.

Stock Hardening Solution

Sodium sulphite (cryst.)	8 oz.	or	200 g.
Glacial acetic acid	6 oz.		150 c.c.
Potash alum (powdered)	8 oz.		200 g.
Water, up to	80 oz.		2000 c.c.

Dissolve the sulphite in 16 oz. (400 c.c.) of warm water and allow to cool. Then add the acetic acid slowly, stirring all the time.

Dissolve the alum in 48 oz. (1200 c.c.) of hot water, allow to cool and then add to the acid sulphite mixture.

Care must be taken that all mixing be done at a temperature below 70°F. (21°C.).

For Permanence. Immediately a print is immersed in the fixing bath it must be moved about so that the solution has free access to back and front. A print paddle made from a strip of hard wood rounded off at one end is invaluable for this purpose, and lessens the risk of hypo getting on the fingers and so into the developer.

The time of fixing should be 10 to 15 minutes at not lower than 60°F. The final print is the consummation of all the efforts of the photographer, and therefore everything must be done to ensure permanence. Prolonged immersion in the fixing bath or the use of a very strong solution of hypo is *not* the way to ensure permanence. We strongly recommend the following system which, if strictly followed, will give prints which should not tarnish with age, and will give pure whites if the prints are after-toned by the sulphide method. The system is based on the use of two separate fixing baths.

1. The prints are placed in a fixing bath and kept on the move for about five minutes. They are then rinsed and placed in a second fixing bath for a further five minutes, keeping them on the move.
2. The second bath must not have been previously used.
3. Not more than the equivalent of 30 prints (5 × 4 in.) should be fixed in 20 oz. of bath No. 1.

The trade worker will find it best to do the work of developing and fixing in batches, roughly calculated in the proportions given above. When one full batch reaches the second fixing bath, No. 1 bath should be thrown away. After the prints have been in the second bath for the second 5 minutes they are removed and washed as usual. This No. 2 bath should not be thrown away, but used as a No. 1 bath for *one* further batch *only*. Working on this system the printer will have the satisfaction of knowing that his prints will be permanent and free from retained silver, which is a contributory cause of tarnish, fading and of impure whites in sulphide toning. This double-bath system may not be convenient to some workers who find that their conditions of working demand a single bath, in which case it is of special importance to avoid over-working the latter.

The necessity for using a second unused bath may be realized when it is stated that Lumière and Seyewetz in the year 1923 showed that any development print which is fixed in a bath containing more than 2·5 g. of dissolved silver salt (from other prints) per litre will show degraded whites *when toned*. A pint of fixing bath will receive this proportion of silver bromide from about twenty half-plate prints!

Note. Prolonged immersion of prints in fresh acid fixing bath results in very considerable bleaching of the image, particularly with warm tone papers.

Washing Prints. For removal of the hypo by washing, numerous mechanical appliances are sold for keeping prints in movement whilst the water passes over them. In purchasing a mechanical print washer it is necessary to be satisfied that prints cannot clot together in a mass (in which state water cannot obtain access to their surfaces), nor be torn or "kinked" by projections in the washing tank. Generally, these washing machines are suited only for prints of small size.

Prints may be washed perfectly by placing them one by one in a large dish of clean water, letting them soak there for five minutes, removing them singly to a second dish of clean water, and carrying out this process 6 or 8 times in all.

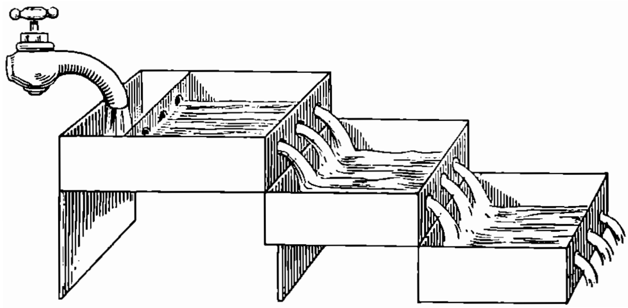


Fig. 75. Cascade print washer (David Allan).

A method which is equally efficient and much less laborious, though requiring a larger consumption of water, consists in the use of three trays arranged as in Fig. 75 through which water flows from the tap. Prints are placed to wash in the bottom tray of this so-called "cascade" washer. When others are ready for washing, the first prints are transferred to the middle tray and their place taken by the new ones. In like manner when a further batch is ready the first prints are put in the upper tank and the second batch in the middle one, leaving the bottom tank for the latest comers. In this way prints are trans-

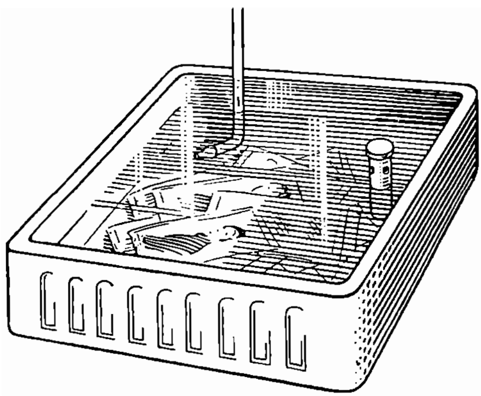


Fig. 76. Washing sink.

ferred from tray to tray against the stream of water, receiving cleaner water as they proceed. For washing larger quantities of prints this type of washer is made with fine jets for the delivery of water to each tray. These afford a more active circulation of water and dispense with the occasional attention required with the simpler pattern.

An exceedingly efficient arrangement for washing prints is shown in Fig. 76. It consists of a good sized stoneware sink fitted with an adjustable overflow; the water is led in by a pipe which is turned at right-angles in the sink and terminates in a fine jet nozzle. The effect of this is to give a circular and also a lifting motion to the water and equally to the prints, which overcomes the tendency of the prints to bunch together and remain in contact.

Where large batches of prints have to be handled the arrangement can be duplicated or increased as desired and such a series of units provides a most practical and efficient method of ensuring thorough washing.

Drying. When thoroughly washed the prints should be placed face upward in a pile on a piece of thick glass, the excess of water squeezed out, the surface of each print wiped gently with soft linen or chamois leather, and the prints laid out on blotters or attached to a line with wooden clips.

An efficient drying apparatus can be made by stretching good quality butter muslin on wooden frames, and placing the prints face downward on the muslin. Prints on papers of glossy surface need not be dried before glazing.

Trade and D. & P. workers use mechanically heated and operated drying machines or drums, having canvas conveyors for the rapid drying of prints.

When dry, a print may be more or less curled. It may be straightened by drawing the back of it several times over the straight edge of a table or by laying it face downward on a smooth flat surface and drawing a straight edge along the back from end to end or corner to corner, lifting the end or corner fairly sharply but steadily as the straight edge is drawn back. Prints dried on heated machines do not require straightening.

Glazing. The glossy surface papers are sufficiently glossy for some purposes when dried naturally, but in order to get a very high gloss it is necessary to squeegee the wet prints to a polished surface and allow them to dry, when they are stripped off with a gloss equal to that of the surface to which they were squeegeed. All Ilford papers are hardened and do not require the use of hardening solutions before carrying out this process, but in very hot weather or under tropical conditions a fixing-hardening bath should be used.

Glass gives the finest gloss, but other surfaces are also suitable, such as ferrotype plates, chromium-plated metal sheets, thick celluloid, or glazed pulp boards. The surface must first be cleaned thoroughly and prepared by treating it with a suitable substance which will facilitate stripping. One method consists in dusting the surface with French chalk, rubbing it in with a clean rag and polishing the surface. Another method is to polish the surface with a solution of beeswax in petrol, but the simplest and probably the best

method is to use a stripping or so-called "glazing" solution consisting of a preparation of ox-gall. There are several of these glazing solutions on the market, and very little is required for a batch of prints. A diluted solution is rubbed on the surface of the glass or other medium, the wet prints having been immersed in the diluted glazing solution are placed into contact with the glass, a sheet of waterproof cloth is lowered on to the prints, and the squeegee (preferably of flat bar pattern) applied. Drying should be carried out in a place free from conflicting draughts.

At the present time, extensive use is made of machines and presses for glazing prints, particularly in commercial photo-printing works, such as those making prints from amateurs' film negatives. In the machines, prints are carried on a rotating heated chromium-plated drum on which they are held in place by an apron. The presses accommodate chromium-plated sheets on which prints are squeegeed and from which they can be stripped off with a high gloss when the plates have been heated in the press for a short time.

Faults in Glazing

Prints refuse to strip when dry. The glass or other surface may be dirty, or the glazing solution exhausted.

Prints show tiny unglazed specks on the glazed surface. The squeegeeing has been too heavy or too light, or the prints contain air from the washing water.

Prints fall from the glazed surface when dry and show "oyster-shell" markings. Uneven drying is the cause, or forced drying by heat which is unevenly distributed.

One method of assisting even drying is to apply to each edge of the print, shortly after placing it on the glazing slab, a strip of damp blotting or other paper about 1 inch in width and overlapping on the glass. This retards the drying of the edges and their premature stripping from the glass.

CLEARING AND TONING DEVELOPMENT PRINTS

Clearing and Reducing Development Prints. In giving detailed instructions for the clearing and reducing of prints by chemical means, we would point out that these operations are usually unnecessary when the technique of printing is mastered. There are, however, exceptional cases where chemical treatment considerably improves the results.

FERRICYANIDE AND HYPO CLEARING BATH

Hypo	1 oz.	or	25 g.
Water, up to	20 oz.		500 c.c.
Potassium ferricyanide saturated solution	1 dr.		3 c.c.

The ferricyanide solution will keep well in an amber or wrapped bottle, or if stored in the dark. The working bath must be freshly

made up and used immediately, as it remains active only for about five minutes. The solution should be used only for very slight clearing or for removing stress marks. The action is rapid and must be used with caution owing to the tendency of the solution to destroy the half-tones.

Prints which are slightly veiled, a trifle over-developed or stress-marked are treated one at a time by passing quickly into the solution and withdrawing almost at once (or when the clearing action takes place) and plunging into running water. The prints are then washed in the usual way.

Iodine-Cyanide Reducer

A.	Potassium iodide	¼ oz.	or	6 g.
	Water, up to	10 oz.		250 c.c.
	Iodine (flake)	20 gr.		1 g.
B.	Potassium cyanide	40 gr.		2 g.
	Water, up to	10 oz.		250 c.c.

For use take 1 oz. (25 c.c.) each of A and B and make up to 20 oz. (500 c.c.) with water. This reducer may be used stronger if desired, according to the nature of the work. Solution B is extremely poisonous and should be so labelled and kept under lock and key.

Decidedly more contrast may be obtained in a print from a flat negative by giving a little more than the normal exposure and considerably more development so that a dark print is obtained, followed by reduction in the reducer. Local reduction may also be effected by applying the reducer with a brush or cotton wool.

When reduction is complete the print is washed for about half an hour and dried.

Iodine-Hypo Clearing Bath

For slight clearing or reducing the print is placed in a bath made by mixing 1 oz. (25 c.c.) of the iodine solution A with 20 oz. (500 c.c.) of water, and after about one minute's immersion transferred to a solution of hypo (2 oz. in 20 oz. of water) until the blue discoloration produced by the iodine disappears. Washing completes the process.

Toning Process. Bromide, Multigrade, and gaslight prints can be after-toned to various colours by the processes detailed in the following pages. The sulphide (double-bath) process of toning is the most popular for bromide prints, and can be used for gaslight prints, but the tones on these papers are inclined to be yellowish. The sulphide method gives beautiful tones on Ilford Bromide Papers, and here working instructions are given for the process. Generally speaking, this process is less suitable for Clorona prints, see "Toning Clorona Prints" on page 285, and for Plastika, with which it gives yellowish tones.

Sulphide Toning. In this process two separate solutions are required—bleacher and sulphide. The print, made in the usual way

by development, fixing, and thorough washing, is placed in the bleacher until the black image is changed to a faint yellowish-brown. It is then washed and placed in the sulphide solution in which it will soon acquire a rich sepia colour. Final washing completes the process, and the tone obtained is permanent.

STOCK BLEACHING SOLUTION

Potassium ferricyanide	1 oz.	or	25 g.
Potassium bromide	1 oz.		25 g.
Water, up to	10 oz.		250 c.c.

This solution should be kept in the dark. For use take 1 oz. (25 c.c.) of stock solution and make up to 10 oz. (250 c.c.) with water.

STOCK SULPHIDE SOLUTION

Sodium sulphide	½ oz.	or	12·5 g.
Water, up to	10 oz.		250 c.c.

Dissolve the sulphide in boiled and cooled water and store the solution in well-corked bottles. The crystals should be examined; any crystals showing signs of deterioration being rejected. For use, dilute 1 oz. (25 c.c.) of stock solution up to 10 oz. (250 c.c.) with water. When the sulphide solution has been used once it must be thrown away.

The tones (or colours) produced by the sulphide process on bromide prints or enlargements vary from cold to warm sepia, according to (*a*) the exposure and development of the black print; (*b*) the quality of the negative; (*c*) the contrast grade of the paper; (*d*) to a slight extent, the surface of the paper and (*e*) the proportion of bromide in the bleaching bath. An over-exposed quickly-developed print gives yellowish tones. An under-exposed print which has been "forced" in development will tone to a colder sepia than one which has had normal treatment. The softer grades of bromide paper give the warmest tones, and the more contrasty grades give colder tones. For obtaining colder tones a useful method is to give the black print a preliminary soak for a few minutes in the sulphide solution, afterwards washing well, bleaching, sulphiding and washing as usual. Reduction of the bromide to a quarter gives warmer tones.

In making up the sulphide working solution, in using it for toning and in the subsequent washing there is the unpleasant odour of hydrogen sulphide (rotten eggs). This can be minimized by having at hand a shallow dish containing some disinfectant, such as diluted Izal or Lysol. When the used sulphide bath is thrown down the sink it should be followed by the disinfectant or by a solution of potassium permanganate, 40 gr. (2 g.); water, 40 oz. (1000 c.c.); liq. ammonia, ·880, ½ oz. (12·5 c.c.).

Sulphide Toning plus Mercury. A variation of the sulphide process was introduced (by H. W. Bennett) in which there is a

certain amount of control of the tone by the addition of mercuric chloride to the bleaching solution. Tone may be varied from warm sepia to warm black by altering the proportions of the two solutions, *viz.*:—

A.	Potassium ferricyanide	1 oz.		25 g.
	Potassium bromide	½ oz.		12·5 g.
	Water, up to ..	10 oz.	or	250 c.c.
B.	Mercuric chloride	¼ oz.		6·25 g.
	Water, up to	10 oz.		250 c.c.

Very hot water must be used for dissolving the mercuric salt.

For a warm sepia (which may vary according to the conditions mentioned on page 275), use A only, diluting 1 part of the solution with 8 parts of water, wash and sulphide as usual. For a cold black tone mix 1 part of B with 2 parts of A and add water to make 12 parts in all; bleach, wash, and sulphide. Intermediate proportions of B give intermediate tones. There is, however, one precaution to take when using this formula, *viz.*, to rinse the prints after bleaching, to pass them through two 1 per cent. baths of hydrochloric acid and to wash for 10 minutes before sulphiding.

Faults in Sulphide Toning

Impure whites. When prints show degraded whites it points to imperfect fixation, or to light or development fog when making the black print. A slight surface fog such as that produced by "forcing" an under-exposed print would probably be invisible to the eye before toning. This may be removed by the iodine-cyanide bleacher given on page 274.

Lack of quality. If the black print is poor in quality the sepia tone will be likewise. Over-exposure and development short of full may be the cause, or the print may have been made on a grade of paper too soft for the negative.

Loss of half-tones. When the lighter details are visible in the black print but are lost after toning, the cause is imperfect washing out of the hypo after fixing the black print. Hypo in the ferricyanide bleacher, or in the washing water after bleaching, will also cause reduction of the fine tones.

Blue stains or spots. Prints bleached in ferricyanide may show blue spots or stains. These are usually due to contamination by iron rust from water pipes or tanks, and can usually be prevented by filtering the water through one or two thicknesses of felt or flannel fastened over the water tap. The spots or stains may be removed by bathing the prints in five per cent. solution of sodium carbonate before the final washing.

Weak yellowish tones. When all other conditions are correct these tones are caused by the sulphide solution being impure, largely exhausted or too dilute. Yellowish tones are also caused by under development of the print.

Blisters. These are caused by using too strong a solution of sulphide, or by prolonged immersion in the sulphide.

Hypo-Alum Toning. In this process the black prints, after fixing and washing moderately to remove the fixing solution, are placed in a solution of hypo and ordinary powdered (potash) alum warmed up to 120°F. (49°C.). In about 10 minutes at this temperature the toning will be complete, and the prints only require washing. The tone given on bromide prints is colder than with sulphide under equal conditions. Clorona prints tone readily in hypo-alum and give beautiful tones which vary according to the exposure and development of the prints. Gaslight prints also tone well, but the vigorous grades are inclined to give purplish tones.

The prints reduce somewhat in toning, therefore they should be rather deeper than the final result required. After fixing and washing they should be placed in the hot hypo-alum solution in which they should be kept moving. The toning bath should be kept as nearly as possible at a temperature of 120°F. (49°C.). The best plan to accomplish this is to use an enamelled iron or porcelain dish which is supported on two stirring rods or thin strips of wood placed in a larger enamelled dish, which is then put over a gas ring or oil stove. The outer dish is filled with water and the toning solution is decanted from the precipitate into the inner dish, which should contain a thermometer. At a lower temperature toning is unduly prolonged, whilst higher temperatures give colder sepia tones. At the temperature recommended toning should be complete in about ten minutes. When the print is toned it should be transferred to tepid water, gradually cooled with the addition of cold water and then washed in water for an hour. Any deposit on the prints should be sponged off before they are taken from the washing water. Prints on Ilford papers do not need to be hardened for hypo-alum toning, as the emulsion is already hardened, but in other cases prints fixed in the ordinary acid fixing bath should be dried before toning, or may be hardened in a supplementary solution of powdered (potash) alum or chrome alum before toning.

HYPO-ALUM TONING BATH

Hypo	3 oz.	or	75 g.
Potash alum (powdered)	½ oz.	or	12·5 g.
Boiling water, up to	20 oz.	or	500 c.c.

Dissolve the hypo in boiling water and add the alum gradually, stirring all the time. The solution will be milk-white owing to the liberation of sulphur. The boiling serves to ripen the bath slightly. A newly-made bath reduces the depth of the prints, but this reducing action becomes less after the bath has been used several times. It can be reduced to a minimum by toning a few waste prints in the bath, or by adding a ripening solution consisting of silver nitrate dissolved in a little distilled water and used in the proportion of

about 5 grains silver nitrate with the addition of just sufficient liquid ammonia to redissolve the precipitate formed, to every 20 oz. of toning solution (0·5 g. per litre). When once a bath is ripened or matured, it will last almost indefinitely if kept up to bulk by the addition of unripened solution from time to time as required.

Factors in Hypo-Alum Toning. A new unripened, or partially ripened, toning bath will give warm sepias on the normal grades of bromide paper and on gaslight or Clorona papers, but the prints will be considerably reduced in depth when toned. A ripened bath gives colder tones but has only a slight reducing action.

The addition of 20 grains (1 gramme) of potassium iodide to each 40 oz. (1000 c.c.) of the toning bath will give warmer tones.

The type of bromide print which tones best in the hot bath is one that has been slightly over-exposed and developed in a developer containing not less than one grain of potassium bromide to each ounce of developer. The print should be slightly darker in the black stage to allow for the slight reduction. A Clorona print produced by giving just the correct exposure to obtain a black print by full development will give a fine warm sepia, but if the print is produced by giving a long exposure, followed by development in a highly restrained developer or in one of the Clorona developers given on pages 283–284, the hypo-alum bath will give a warmer sepia tone.

With both bromide and gaslight papers the softer grades give warmer colours with hypo-alum toning than the more vigorous grades.

Faults in Hypo-Alum Toning

Blisters. When blisters occur or the emulsion melts, the prints have not been sufficiently hardened (Ilford papers are already hardened), or the temperature of the toning bath has been too high. If blisters appear during washing after toning, there has been too sudden a drop in the temperature when transferring the toned print from its hot bath to cold water.

Prints are patchy. When parts of the image are unevenly toned, the cause is usually lack of complete washing out of the fixing solution or by the prints adhering to one another during toning.

Tones are too cold. Consult page 277 for the factors affecting the tone.

Loss of depth. The image may show considerable reduction after toning in a new unripened bath. If due allowance is not made for the slight reduction which a ripened bath gives, the prints will be too light after toning.

Liver-of-Sulphur Toning. This is a simple one-solution process giving excellent warm tones on Clorona and gaslight prints, but colder tones on bromide prints. A stock solution of liver of sulphur is made by dissolving 1 oz. in 10 oz. of hot water (25 g. in 250 c.c.). A working bath is made up with ½ oz. of stock to 80 oz. (12·5 g. to 2000 c.c.) of water and 20 drops of ammonia ·880 (1 c.c.) and is used at about 80°F. (27°C.). The liver of sulphur must be fresh.

The black prints are taken from the fixing bath, which should be of the fixing-hardening type (see page 269), washed for a few minutes and placed in the working bath. Toning takes place rapidly in the case of Clorona and gaslight prints and is complete in about 4 minutes; bromide prints take longer. The toning action continues in the washing water, whilst a further change of colour occurs in drying. The washing should be thoroughly carried out to remove any general discoloration of the whites.

N.B.—In all sulphide-toning processes (sulphide, hypo-alum, liver of sulphur), sulphuretted hydrogen is evolved. This gas not only has a highly objectionable smell; it has also a very harmful effect on all photographic materials. For both reasons care is necessary to carry out the operations in well-ventilated places, preferably where the vapour escapes into the open air, and certainly where it has no chance of reaching rooms or cupboards where photographic materials are stored.

Red and Blue Tones. By the use of methods of after-toning, the black of development prints can be changed to quite a variety of colours, but with the possible exception of the red-toning process these special colours are not considered to be permanent. We give below working formulæ for the red and blue tones only.

RED-TONING BATH

Ammonium sulphocyanide ..	30 gr.	or	2 g.
Chloride of gold	2 gr.		0·1 g.
Water, up to	4 oz.		100 c.c.

Dissolve separately and mix by adding the gold solution gradually to that of the sulphocyanide. This bath gives a good red chalk tone. Prints must have been previously toned by either of the sulphide, hypo-alum, or liver-of-sulphur processes. The process is an expensive one, since a 6×4 in. print will require about one grain of gold chloride. For light sketchy portrait vignettes printed with ample white margins, this toner is very effective, and is best applied to the damp print with cotton wool. For toning "solid" pictures it is best to immerse the prints in the solution, rocking the dish all the time. When the required tone is reached the print must be rinsed, fixed, and washed. Bromide, Clorona, or gaslight prints give good results; the brighter reds being obtained on gaslight or Clorona prints.

When used on a black print, this red-toning bath, with a short immersion, gives a bluish-black tone and is a useful means of improving the colour of a greenish-black print.

BLUE-TONING BATH

Ferricyanide Solution

Potassium ferricyanide	20 gr.	or	1 g.
Sulphuric acid, conc.	40 m.		2 c.c.
Water, up to ..	20 oz.		500 c.c.

Iron Solution

Ferric ammonium citrate	20 gr.	or	1 g.
Sulphuric acid, conc. ..	40 m.		2 c.c.
Water, up to	20 oz.		500 c.c.

In both cases the solutions are made up by first dissolving the salts in the water and then adding the sulphuric acid slowly. The acid must always be added to the solution—to add a solution to acid is highly dangerous.

The working bath is made by mixing equal parts just before use. Development prints intended for toning in this blue-toning bath must have been thoroughly freed from hypo, and should be somewhat light in depth. They are immersed for a minute or so until the blue colour is reached, placed immediately in running water for about one minute, or until the yellow colour has gone from the whites, and hung up to dry after wiping or blotting off all drops of water. If washing is unnecessarily prolonged the blue image will be reduced; this result may be prevented by washing in water slightly acidulated with hydrochloric acid until the yellow stain has gone, and then in ordinary water for such time as is necessary to remove the acid, but no more.

Faults in Development Prints

Abrasion or stress marks. These defects, in the form of fine lines, hair-like markings or grey patches, sometimes make their appearance when the sensitive paper has been roughly handled before development. The printing apparatus may have some protruding metal part, or the corner or edge of the negative may have scratched the emulsion surface. To remove the dark markings, pass the prints through a weak reducer such as ferricyanide and hypo (page 273), or a clearing bath of iodine in potassium iodide (page 274), or rub the surface of the dry prints with a soft rag dipped in a mixture of equal parts of methylated spirit and ammonia (such defects do not occur on Ilford papers if carefully handled, as these papers are specially treated to prevent them).

Blisters. These may be caused by wide variations in temperature of developer, fixing bath and washing water, by too strong a fixing bath or by too long immersion in it. Blisters on sulphide-toned prints may be caused by too strong a sulphide solution. Hypo-alum toned prints may blister if the prints are put straight from the hot toning bath into cold washing water instead of through an intermediate bath of tepid water. Mechanically produced blisters are caused by creasing or folding the paper, or by the strong local action of water in washing.

Colour of Image unsatisfactory. Bromide or gaslight prints which are greenish in colour indicate under-development due to over-exposure, too great a proportion of potassium bromide in the developer, or too much dilution of the developer. The latter, especially, applies to gaslight prints.

Contrast excessive or lacking. Excessive contrast generally indicates the use of the wrong grade of paper. Specially soft grades of paper are made for printing from "hard" contrasty negatives. Excessive contrast may also be caused by under-exposure and over development of the print.

When contrast is lacking, the cause may also be the wrong choice of paper. Thin, poor negatives require printing on the vigorous or contrasty papers and will give brilliant prints in this way. Another cause of poor contrast is the use of a partially exhausted or improperly compounded developer, or the use of the developer at too low a temperature. Poor contrast may also be caused by over-exposure, followed by short development.

Deposits on dry prints. When caused by the use of hard water the deposit can usually be removed by wiping the surface of the wet print before drying. Prints which have been insufficiently washed after fixing may show a deposit of white powder or crystals. Prints toned in the hypo-alum bath may dry with a bad surface unless well sponged when removed from the toning solution. Sulphide-toned prints will show patchy alkaline deposits if inadequately washed after toning. Deposits can also be removed mechanically by applying to the surface of the dry print a little metal polishing paste on a piece of soft rag, followed by polishing with a clean rag. Beeswax dissolved in petrol, or ordinary wax floor polish, will often improve a bad surface.

Fading or tarnishing. Incomplete removal of the unused silver salts by the fixing bath or failure to remove all the hypo may cause fading or tarnishing (see page 269). Impurities in the mount or the use of an acid mountant may also cause fading. Keeping the prints in an impure atmosphere may cause yellowing or tarnishing.

Fog or degraded whites. A grey veil over the surface of a print may be caused by:—

(*a*) Exposure to light or an unsafe darkroom light before or during printing or developing.

(*b*) Prolonged development beyond the usual full time, or with the developer at too high a temperature.

(*c*) Using an incorrectly made up developer, or one with insufficient potassium bromide.

(*d*) Storing the sensitive paper in an unsuitable place—see "Packing and Storage" (page 262).

Mottle or patches. Bad storage of the sensitive paper, or failure to keep the print moving in the developer, fixing or other bath, may cause these defects. Patches on gaslight prints are usually caused by failing to move the developed prints as soon as they are first placed in the fixing bath, especially if the acid content in the fixer is exhausted.

Spots. White spots, other than those caused by defects on the negative, are the result of air-bells forming on the surface of the print during development. Particles of chemicals, either as dust or solution, particularly of hypo, falling on the surface of the paper may cause black or white spots. Dark spots are usually caused by air-bells during fixing. Blue spots are referred to on page 276 in "Faults in Sulphide Toning."

Stains. The yellow stains which sometimes make their appearance chiefly on gaslight prints are caused by prolonged development, by too long exposure to air between development and fixation, by imperfect fixing or by insufficient acid in the fixing bath. A mere trace of hypo in the developer or on the fingers when handling the print previous to development may cause stains.

CHLOROBROMIDE (CLORONA) PAPER

Clorona Printing. The ever-growing popularity of Clorona paper has prompted us to devote a special section to it. Designed originally for professional portrait photographers for the production of warm-toned prints by direct development, this paper is now being used for a variety of subjects and by amateurs for pictorial work.

Exposure with Clorona. The term "correct exposure," when used in connection with bromide or gaslight papers, has a restricted meaning since it is used almost invariably with regard to one developer and one tone only, although a change of developer might necessitate a change of exposure to give a similar result. With Clorona, however, the position is by no means the same. The tone of a Clorona print, as will be seen in the details given below, is determined by the composition of the developer and the length of time of development. A "correct exposure" with Clorona is the exposure required to ensure an image of good density when development has been carried far enough in the chosen developer to give the desired tone; naturally, the "correct exposure" therefore can vary within wide limits. Another way of expressing it is to regard as a "normal" exposure (equivalent to "correct" exposure for bromide papers) that required to give a black (or warm black) image with a normal M.Q. developer (the first one given on page 283) and to say that warm tones are obtained by "over-exposure" and prolonged development in a dilute and highly bromided developer.

Developers for Clorona. The M.Q. developer is suitable for tones (colours) of the warm-black variety. The chlorquinol M.Q. developer gives tones ranging from warm-black to brown and sepia. The chlorquinol-hydroquinone developer gives excellent tones from sepia to red-chalk if used according to the table which follows the formula.

M.Q. Developer for Warm-Black Tones ID–25

Metol	10 gr.	or	0·5 g.
Sodium sulphite (cryst.) ..	½ oz.		12·5 g.
Hydroquinone	30 gr.		1·5 g.
Sodium carbonate (cryst.)	½ oz.		12·5 g.
Potassium bromide ..	30 gr.		1·5 g.
Water, up to	20 oz.		500 c.c.

Development should be complete in about 1½ minutes at 65°F. (18°C.). This developer is suitable for warm-black tones. Colder or warmer tones can be obtained by considerably reducing or increasing the quantity of potassium bromide.

Chlorquinol M.Q. Developer for Warm-Black to Sepia Tones ID–23

Metol	10 gr.	or	0·5 g.
Chlorquinol (or Adurol)..	¼ oz.		6·2 g.
Hydroquinone	¼ oz.		6·2 g.
Sodium sulphite (cryst.) ..	4 oz.		100 g.
Sodium carbonate (cryst.)	4 oz.		100 g.
Potassium bromide ..	15 gr.		0·8 g.
Water, up to	80 oz.		2000 c.c.

This developer is suitable for tones ranging from warm-black to sepia. For warm-black one part of developer is mixed with three parts of water and for sepia the exposure should be increased by about 50 per cent. and the developer diluted with six parts of water. In either case, development should take about 2 minutes at 65°F. (18°C.).

Chlorquinol-Hydroquinone Developer for Sepia to Bright Red Tones ID–24

Chlorquinol (or Adurol)..	60 gr.	or	3·4 g.
Hydroquinone	60 gr.		3·4 g.
Sodium sulphite (cryst.) ..	2½ oz.		62·5 g.
Sodium carbonate (cryst.)	2½ oz.		62·5 g.
Potassium bromide ..	6 gr.		0·3 g.
Water, up to	20 oz.		500 c.c.

With increasing exposure, greater dilution of developer, and more potassium bromide, the colours produced range from sepia to bright red as indicated in the following table. Time of development may be from 2 to 30 minutes according to the colour required. Development may be speeded up by using the solution at 70° to 80°F. (21° to 27°C.).

TABLE FOR COLOUR CONTROL

Using developer on page 283, *i.e.*, ID–24, at 65°F. (18°C.).

Colour	Exposure	Dilution of Developer	Extra 10 per cent. Potassium Bromide solution per oz. (25 c.c.) of Stock Developer	Approx. Time of Development Minutes
Warm-black	Normal	Full strength	None	$1\frac{1}{2}$*
Sepia	3 times	10 times	20 minims (1 c.c.)	5
Brown sepia	5 times	15 times	60 minims (3 c.c.)	10
Red brown	6 times	25 times	100 minims (5 c.c.)	15
Bright red	7 times	30 times	120 minims (6 c.c.)	20

* This line is added to indicate the general tendency of the alterations; if a warm-black tone is desired it is better to use one of the other developers.

GLYCIN-HYDROQUINONE DEVELOPER

A developer obtained by replacing chlorquinol by an equal weight of glycin and by increasing the sodium carbonate to 4 oz. (100 g.) in the formula ID–24 (page 283) gives a similar range of tones used according to the following table:—

Colour	Exposure	Dilution of Developer	Extra 10 per cent. Potassium Bromide solution per oz. (25 c.c.) of Stock Developer	Approx. Time of Development Minutes
Warm-black	Normal	Full strength	None	$1\frac{1}{2}$
Sepia	2 times	5 times	20 minims (1 c.c.)	5
Brown sepia	3 times	10 times	60 minims (3 c.c.)	10
Red brown	4 times	15 times	100 minims (5 c.c.)	15
Red	5 times	20 times	120 minims (6 c.c.)	20

By normal exposure in both tables is meant that required for a warm-black tone with the metol-hydroquinone developer first given for this paper.

The quality of the negative plays an important part in the production of warm colours by direct development; the best results are obtained from negatives of good contrast and printing density.

After development the procedure of fixing and washing is precisely the same as for bromide or gaslight papers.

Judging Colour of Clorona Prints. When developing the prints in the ordinary yellow light of the darkroom or printing room it is difficult, if not impossible, to judge the very warm colours correctly.

As a matter of fact, the colour of the print whilst wet in the developing and subsequent operations is not the same as that which comes after drying, but a little experience will enable the worker to make due allowance for the change. It is a good plan to fit up a special white inspection light containing a frosted low candle-power lamp of about 5 c.p. and occasionally to make a rapid inspection of the progress of development. The lamp must be so placed in the dark-room that it cannot shine on the ordinary work-bench or cause fog on the paper at any stage.

When a test print, made under known conditions of exposure, dilution of developer, time of development, etc., proves satisfactory, these conditions must be correctly duplicated when making the batch of prints. It should be remembered that the tone is dependent on the composition and temperature of the developer and on the time of development. If these have been determined for a particular tone for a particular negative, they will be the same for the same tone for another negative, but the *exposure* must be *carefully adjusted* to give the required strength of print under these development conditions.

Toning Clorona Prints. The range of colours readily obtainable by suitable development of Clorona renders processes of after-toning of much less importance in the case of this paper. Moreover, Clorona prints behave somewhat differently from those on other papers when treated by the regular toning processes previously described. Hypo-alum is very suitable for Clorona, which yields fine sepia tones by this process. The usual two-bath process of sulphide toning tends to give yellowish prints, but very good sepias are obtained by using a bleach made as follows:—

Potassium ferricyanide	½ oz.	or	12·5 g.
Potassium bromide ..	5 oz.		125 g.
Water, up to	50 oz.		1250 c.c.

Also, warm black prints on Clorona yield very fine effects if *very slightly* bleached in a very weak solution of the standard bleach (p. 275) and then darkened with sulphide.

Failures in Clorona Printing

The print is lacking in contrast. The negative may not be contrasty enough. Clorona requires a negative of fair contrast, especially when very warm tones are required. In cases where Clorona warm-tone prints are wanted from a very poor negative, it is advised to expose sufficiently to allow of a full two minutes' development in the M.Q. developer given for gaslight papers (page 267), and then, after fixing and washing, to tone the prints in the hypo-alum or liver-of-sulphur bath. Lack of contrast may also be caused by failure to get the proper balance between exposure and the developer used.

The warm colours lack quality. Here again the negative may be at fault, or the print over-exposed. Under-development may be the cause, or too long an immersion in the fixing bath, or the developer may be too cold.

Yellowish colour when sulphide-toned. Prints intended for toning should not be developed to a warm colour, but must have been correctly exposed to get a black colour when developed to finality.

Patches of double tones. Caused by failure to keep prints moving during development or during the first minute of their immersion in the fixing bath. An acid fixing bath should be used as with bromide and gaslight papers.

ILFORD PLASTIKA

Possessing a characteristic curve with a long straight line portion this new paper accurately matches the gradation of modern negative materials—it is this fact which explains its success and popularity. Sensitometry has shown that straight line reproduction makes for correct reproduction and this is what the photographer must have if he is to produce pictures with satisfactory modelling, if he is to reproduce the subtle variations in adjacent tones which constitute texture and roundness and if he is to secure full value for the thought he has given to the lighting of the subject.

Plastika has a speed of about half that of ordinary bromide paper. The image colour is black with just a hint of warmth and the emulsion characteristics are such that particularly pleasing results are obtained from even the most difficult negatives. When used with enlargers of the mercury vapour type the speed of Plastika relative to bromide paper is reduced and the results obtained are rather softer.

The Ilford "S" Safelight No. 902 gives the maximum illumination consistent with safety and is strongly recommended for use with Plastika. It should be noted that some safelights which are normally recommended for use with bromide paper may, with Plastika, give rise to fog.

Ilford Standard M.Q. Developer ID-20 is specially recommended, but any of the usual M.Q. developers may be used with success.

Plastika is treated exactly as an ordinary bromide paper, *but if exposure has been correct the image will appear in about* 15–25 *seconds.*

Full detail appears in 35 to 45 seconds, after which the darker portions and shadows gradually build up with continued development, giving maximum quality within a period of 1½–2 minutes at a temperature of 65°F. (18°C.). Little further change takes place after this time but the development may be continued without any detriment up to 2½ minutes.

If the temperature is high, namely, 75°F. to 80°F. (24°C. to 27°C.), maximum development takes place in about one minute and the print should be removed from the developer when full density is reached.

There is great latitude in exposure and time of development. An over-exposed print develops more rapidly and can be removed from the developer in from 35 to 45 seconds *without* loss of quality.

For those who prefer warmer tones, pleasing sepia images of consistent hue are readily obtainable with ID–49.

ID–49 ILFORD PLASTIKA WARM TONE DEVELOPER

Metol	6 gr.	or	0·35 g.
Hydroquinone	54 gr.		3·0 g.
Chlorquinol	54 gr.		3·0 g.
Sodium sulphite (cryst.)	4 oz.		101 g.
Sodium carbonate (cryst.)	1¼ oz.		33·0 g.
Potassium bromide	15 gr.		0·9 g.
Water, up to	80 oz.		2000 c.c.

This developer should be used at full strength and exposure should be such as to yield satisfactory prints in from 1½–4 minutes development at 65°F. (18°C.) according to the warmth of tone desired.

Alternatively, the Ilford Chlorquinol M.Q. Developer ID–23 may be used, the formula for which is given on page 283. For use, dilute 1 part with 3 to 6 parts of water, according to the shade of sepia preferred.

SURFACES AND GRADATIONS

	Soft	Normal	Contrasty	Extra Contrasty
Glossy Single Weight	A1	A2	A3	A4
Glossy Double Weight	A1K	A2K	A3K	A4K
Matt Double Weight ..	—	B2K	B3K	—
Grained Half-Matt, D.W.	F1K	F2K	F3K	F4K
Cream Grained Half-Matt, D.W. ..	T1K	T2K	T3K	—
Cream Semi-Matt, D.W.	P1K	P2K	P3K	—
Cream Matt D.W. ..	R1K	R2K	R3K	—

ILFORD MULTIGRADE PAPER

Among the several important factors which are involved in the production of a satisfactory photograph is the control of contrast, both in the negative and in the subsequent positive print. So far as negative materials are concerned, it is possible to vary the contrast over a wide range by alteration of development time and by changes in the character and composition of the developer. With positive printing papers, on the other hand, development can be varied only within narrow limits; in general, emulsions of this kind must be developed right out.

At one time, printing papers were manufactured in one contrast only, and it was the standard practice to control the gradation of

each negative by individual development in order to produce a satisfactory print from the paper available. The introduction of roll films, however, made this method of working impossible and led to the manufacture of papers in several contrasts. In recent years, the rapid growth in popularity of the miniature camera, resulting in the development by the time and temperature method of as many as thirty-six exposures on one length of film has added still further to the difficulty of matching the paper to the gradation of each individual negative, and has resulted in the marketing of bromide papers by some manufacturers in as many as seven different contrasts. The employment of so many grades has the disadvantage that stocks must be kept of contrasts which will seldom be used and, owing to the demand for a wide variety of surfaces, is particularly unsatisfactory because it is possible to supply only the more popular surfaces in all degrees of contrast.

The search for a method by which the contrast of the print can be controlled as readily as that of the negative has led to the introduction of Multigrade, an Ilford development paper from which any desired contrast may be obtained by varying the colour of the printing light. It is now possible, with one grade of paper only, to produce perfect prints from negatives of any contrast—Multigrade does the work of all the grades comprised in the entire range of bromide papers—soft, medium, normal, vigorous, contrasty, extra contrasty and ultra contrasty, and is, moreover, capable of an exceedingly fine degree of control. These advantages are further enhanced by the fact that the methods of control apply equally to all the surfaces in which Multigrade is supplied.

How Multigrade Works. In order to understand how variation in the colour of the printing light brings about change of contrast, it will be necessary to discuss briefly the method by which Multigrade is manufactured. The paper is coated with an emulsion, part of which is not colour sensitized, while the remainder is sensitized to the blue-green region of the spectrum. That portion which is sensitized to blue-green light is of a very contrasty character, equalling in this quality the ultra-contrasty grades of bromide paper, while the non-colour sensitized portion is softer in gradation than the softest grade of bromide paper. Thus, it is only necessary to regulate the relative extent to which each of these two components is affected during exposure to modify the gradation of the resultant print to any desired value between the extreme characteristic of each component.

The balance between the two components is so adjusted that for exposures to the unfiltered light of an incandescent tungsten lamp, the greater proportion of the image is formed on the extra soft element with the result that, when used in this way, Multigrade acts like a soft bromide paper. It is clear, therefore, that removal from

the exposing light of part of the blue-violet radiation to which the non-colour sensitized component responds, will result in the formation of more of the image on the colour-sensitized and contrasty component, and that the increase in contrast produced in this way will depend on the extent of the blue-violet deficiency.

Control of the blue-violet content of the printing light is most conveniently brought about by means of colour filters. Those who are already familiar with the use of colour filters on the camera are, of course, aware that violet and blue absorbers are yellow in colour, and a special series of five yellow Multigrade filters has been produced by Ilford Limited. These are graduated in strength from very pale yellow to deep yellow, and provide a range which, starting from the palest, applies a definite and increasing amount of blue-violet absorption until on reaching the strongest filter sufficient of the short wavelength radiation is absorbed to leave the soft component of the emulsion entirely unaffected during exposure. Thus, with the aid of the five filters, it is possible to produce a series of six contrasts, from soft to ultra-contrasty.

The use of the five yellow filters provides the basis of the first of the methods of handling Multigrade which will now be described.

Exposing Multigrade

First Method.—The five yellow filters are numbered M4, M6, M8, M10, and M12 in order of increasing depth, and for exposures to gas-filled electric lamps the equivalent bromide paper contrasts are given in the following table:—

Multigrade Filter with Multigrade Paper	*Equivalent grade of Ilford Bromide Paper*
No filter	Soft
M4 (pale yellow)	Normal
M6 (light yellow)	Vigorous
M8 (medium yellow)	Contrasty
M10 (deep yellow)	Extra Contrasty
M12 (MASTER YELLOW)	Ultra-Contrasty

All that the user has to do in applying this method is to examine the negative to be printed, decide from its density range which bromide contrast would normally be required, and then carry out the exposure on Multigrade paper with the aid of the appropriate filter as indicated by the table. Negatives adapted for printing on Multigrade with the different filters will be of different density ranges, but if these ranges all start from a common low level of density in the shadow region of the subject, the user will find that roughly the same printing exposure is required whichever filter has to be used. Thus, the user can estimate what exposure to use by examining the shadow densities of his negative. If these vary from one negative to another the exposure necessary to yield the best print with the chosen filter may be found in the usual manner by means of test prints or test strips.

Second Method.—This method will have a special appeal to many, especially after some experience with Multigrade, since by the employment of a relatively simple technique it permits the most delicate adjustment of contrast and requires the use of only one filter, the M12 (Master yellow). Exposure is made partly through this Master filter and partly with unfiltered light, the relative lengths of the two portions of the exposure being adjusted to produce the contrast required. Although an infinite choice of contrasts is theoretically possible, it is found that a subdivision of the total exposure into ten units is quite sufficient for normal purposes. On this basis, exposures may be made up with ten units of white light and none of yellow, nine units of white and one of yellow, eight units of white and two of yellow, and so on. As an approximate guide to the range of contrasts thus produced, the following table will be found extremely useful.

Contrast Factors (*Relative proportions of white and yellow light*)		*Resultant Print* (*Equivalent grade of bromide paper*)
White	*Yellow*	
10	0	Soft
6	4	Normal
4	6	Vigorous
3	7	Contrasty
1	9	Extra Contrasty
0	10	Ultra-Contrasty

The practical procedure with this method is in reality very simple, although on paper, at least, the calculation of the necessary exposure may appear a little complicated. It is first of all necessary to make a test print without filter in order to determine the time required to print the middle tones of the negative to the correct depth. This provides a basis on which to calculate the subsequent mixed light exposure, and in conjunction with a careful examination of the negative, the print may be used to judge which bromide paper contrast would best suit the subject. (The test print from a negative of good range and average contrast will normally be softer than is finally needed, having too much density in the highlights and too little in the shadows.) Reference to the above table will then show the correct proportions of white and yellow light to use in making the Multigrade print and the printing time as determined by the test exposure is subdivided accordingly. At this point, allowance must be made for the light absorption of the Master filter, which has an exposure factor of 4, and it is necessary, therefore, to multiply the calculated yellow light portion of the exposure by this amount. A very little practice will soon make it a simple matter to decide upon the correct proportions of white and yellow light required for each negative.

The following practical example will make the method of calculation clearer. Let us consider the case of a negative whose contrast is such as to require printing on Vigorous bromide paper. A trial exposure to white light is made and found to require 20 seconds. The calculation proceeds on the following lines:—

Test exposure without filter = 20 seconds.
Vigorous bromide paper = Contrast factors of 4 (white) and 6 (yellow).

The mixed light exposure will thus be divided as follows:—

Four-tenths of 20 = 8 (white light portion).
Six-tenths of 20 = 12 (yellow light portion).
But exposure factor of yellow Master filter = 4

Hence the necessary exposures are:—

White light .. .. .. 8 seconds.
Yellow light .. .. .. $12 \times 4 = 48$ seconds.

Quality of Negatives for Multigrade Printing. Multigrade paper makes it possible to obtain perfect prints from such a wide variety of negatives that it is well to remember here, as with other printing processes, that the negative, whatever its gradation, must include within its density range all the tone values which are intended to be recorded in the final print. No printing paper can be expected to possess the magic power of discovering subtle tone differences which are absent from the negative, nor can it reproduce interesting shadow detail from areas of film entirely clear through underexposure.

In order that exposures through the filters may be kept reasonably short, it is advisable that negatives for enlargement should not be unduly dense, and it is important that they should be free from chemical stain which, because of its colour, can exercise a disturbing influence over the control of gradation.

Darkroom Lighting. Since a portion of the Multigrade emulsion is colour-sensitized, the importance of correct darkroom lighting cannot be over-emphasized. Many of the safelights used for handling bromide paper are most definitely unsafe with Multigrade, and much annoyance and disappointment will be avoided, therefore, if the darkroom lamp is fitted with the recommended safelight, an Ilford "S" Safelight No. 902 and a bulb of power not exceeding 15 watts. In the same way certain enlarger safety caps are unsuitable for Multigrade, but here again a safety cap containing the Ilford "S" Safelight is satisfactory when used with care.

Processing. Apart from the unique method by which the gradation of Multigrade prints is controlled, the paper is handled in exactly the same manner as an ordinary bromide paper and has the same general characteristics. It may be developed in any normal M.Q. or Amidol formula, but the standard Ilford ID-20 formula, which yields prints of a fine neutral black colour irrespective of

the colour of the printing light, is particularly recommended, the correct time of development being $1\frac{1}{2}$–2 minutes at 65°F. (18°C.).

One point of difference from bromide papers should, however, be noted. Whereas with bromide papers the shadows build up towards the end of development, the reverse occurs in the case of Multigrade, where the shadows build up at an early stage of development and highlight detail appears last.

After development the prints should be rinsed and placed in an acid fixing bath as for bromide paper.

After-treatment of Prints. Multigrade responds particularly well to toning, and gives a fine sepia by the sulphide method. By using both the white and cream base varieties, a wide range of image colours can be produced.

Contact Printing. Either of the methods already described for use with enlargers may be employed for contact printing, and in order to simplify the application of either of these, a special unit, called the Multigrade Printing Box No. 1, has been produced by Ilford Limited. It consists of a lamphouse fitted on one side with a small window into which any of the Multigrade filters, in the form of lamp-filters, can be inserted.

A second and more elaborate device to assist the contact printer is the Multigrade Printing Box No. 2. This is a light-integrating apparatus in which the required proportions of the printing lights are thoroughly mixed before emerging from the outer opal window against which the printing frame is placed. The light mixture is controlled by means of an external lever which moves over a graduated scale indicating the degrees of contrast which will be obtained at a number of settings throughout the range.

Types of Filters. Multigrade filters can be supplied in the following forms:—

Gelatin film—available in special rectangular cardboard mounts, or may be supplied unmounted cut to any required size.

Glass filters in slip-on metal mounts—of good optical quality, for use with enlargers, in sizes to order.

Glass lamp filters—to fit Multigrade Printing Box No. 1 and available to order to fit contact printing boxes, printing frames, etc.

Multigrade Surfaces. Ilford Multigrade paper is available in the following surfaces:—

Glossy ..	.. Single weight.
Velvet ..	.. Single weight.
Silika White	.. Double weight.
Silika Cream	.. Double weight.
Cream Matt	.. Double weight.

It will be clear from what has been said that the handling of Multigrade is no more difficult than that of ordinary bromide paper. In brief, it becomes merely a question of selecting the appropriate filter or light mixture, according to the exposure technique employed, instead of choosing the correct grade of paper from a selection of six or seven contrasts. Having regard to the fact that Multigrade avoids the necessity for keeping in stock many rarely used grades of paper, it is obvious that the resultant economy will very soon more than cover the extra cost of the colour filters.

Once the art of handling Multigrade has been mastered, endless possibilities will suggest themselves, such as combination printing from negatives of different contrasts, and the variation of contrast in selected areas of the subject by means of local control. The introduction of Multigrade undoubtedly represents the greatest advance which has been made in the manufacture of printing papers for many years.

SPECIAL DEVELOPMENT PAPERS

The numerous branches of science and industry have special requirements in connection with which special photographic products have been prepared. It is not possible to enumerate them all, but mention may be made of three bromide papers which have a fairly extensive use.

Dry Transfer Paper. By means of this paper it is possible to transfer the photographic image to any other suitable support, a proceeding which may be of great value in certain decorative industries. In practice this paper is employed exactly as bromide paper; after processing and washing, the wet print is stuck down by means of an adhesive, allowed to dry, and the paper base then stripped off, leaving the image firmly adhering to its new support. A fixing-hardening bath should be used. By careful choice of subject and support, highly decorative effects can be obtained.

Document Paper. The photographic copying of documents, printed matter of all types, cheques, blue-prints, etc., is a matter of very considerable importance. While such work could be done by any ordinary photographic means, quicker and more economical standardized methods have been devised. A special camera is employed which holds a roll of a special type of bromide paper—Document Paper—in such a way that the paper is held flat and the negative taken through a reversing prism direct on the paper. In most of such cameras the exposed sheet of paper is then cut off and passed directly into a developing tank at the back of the camera and then through fixing and washing baths, so that the completed paper negative can be in the washing water within two or three minutes of making the exposure.

The negative images prepared thus are frequently all that is required, since the white letters on a black ground are readily legible. If a positive image is desired the negative is re-photographed in the same camera and a good reproduction of the original is produced.

Negative Card. This is a low-priced substitute for plates or films for use in the camera—although it cannot be said to yield results of the same quality. It is supplied by Ilford Limited in two qualities, both on double-weight or postcard thickness of support—Studio Negative Card and Outdoor Negative Card. They differ chiefly in speed, the former being slightly faster than Iso-Zenith and of softer gradation than the latter which is about S.R. speed. The paper is handled as bromide paper, special attention being given to the darkroom illumination because of the high speed. As printing is by reflection, this can be done before drying of the negative, a considerable advantage where a quick result is necessary. The technique of negative making is not difficult, but rather different from that followed in the making of transparency negatives. The subsequent printing operation consists in copying the card negative in the camera by means of light incident upon the negative and reflected from it. It follows that the silver deposits on the negative will all have effectively twice the density they would have on film and if printing were to be by projection and for the same reason the effective contrast of the negative will be increased. For this reason the negative should have relatively short development. Exposure should also be on the short side to prevent the production of too great a density in the highlights. Remember any light passing through the emulsion is reflected by the card base to make the position worse. The real criterion of a good negative is that there should be neither pure white nor full black on any part of the image. Fog must be avoided at all costs. Normal practice is to make the positive print on Vigorous Bromide paper, and provided that the negative has been made according to the advice given above a satisfactory print will be obtained.

Paper for Recording Instruments. Different kinds of paper varying widely in speed are required for the various instruments on the market. Orders should always be accompanied by complete details of the instrument in question, and by information as to whether the paper is to be supplied with or without perforations.

CHAPTER XIV

CONTACT AND PROJECTION PRINTING

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CONTACT PRINTING

Contact printing on "Gaslight" paper can be carried out quite easily and successfully with normal artificial light illumination. The sensitive paper must not be exposed directly to the light except when it is being purposely exposed behind the negative. During processing, the direct light may be screened by means of a book or card, or by the operator's body. If a darkroom is available the work can very conveniently be done in the light transmitted by a bright yellow safelight. The Ilford S. Safelight No. 902 in conjunction with a 25-watt lamp is suitable, but if this lamp causes the lamphouse to heat unduly an Ilford V.S. Safelight No. 901 should be used in conjunction with a lamp of lower wattage. An unscreened lamp must be available for the making of the actual exposure.

Bromide, Clorona, Plastika, and Multigrade Papers must be handled and processed in rooms lit by yellow or amber light, and white light must be carefully excluded. With many kinds of bromide paper the actual quality of the yellow light is unimportant, but for Plastika and Multigrade it is essential to use care in the selection of a safelight. Some safelights, which are quite safe with bromide papers, cause fog with Plastika and Multigrade, but the Ilford S. Safelight No. 902 is quite safe with the entire range, and may be used with confidence.

Apparatus for Contact Printing. Contact prints may be made either on Bromide or Contact (Gaslight) Paper and conditions of work will, of course, depend upon the choice. The simplest apparatus of all is the wooden or metal printing frame. It is best to choose a frame about two sizes larger than the negative, *e.g.*, a half-plate ($6\frac{1}{2}$ in. $\times$ $4\frac{3}{4}$ in.) for a $3\frac{1}{2}$ in. $\times$ $2\frac{1}{2}$ in. negative, which makes it possible to mask the negative and to produce $3\frac{1}{4}$ in. $\times$ $2\frac{1}{4}$ in. pictures with white margins. With such a frame exposure is made to an ordinary half-watt lamp situated twelve inches away.

Contact printing boxes can be obtained in which both the printing light and a safelight are fitted, the latter making it possible to position the negative and printing paper. The printing light is automatically put into operation on closing the pressure plate. Printing boxes, for the professional and trade worker, range in design from the more robust form of boxes as described above, to complicated machines devised for the production of long runs, using paper in continuous rolls.

A contact printing box in which it is possible to vary the strength of illumination, is particularly useful when it is necessary to use

papers of varying speeds, such as Bromide, Contact (Gaslight), and Clorona.

Exposure in Contact Printing. The necessary exposure depends on the light source and its distance from the negative, the presence or absence of a reflector, the density of the negative, and the speed of the paper. It is well to remember that the contrasty grades of paper are usually slower than the soft grades. Hard papers are generally used with thin negatives, however, and with Ilford Bromide and Contact (Gaslight) Papers, the speeds of the various gradations have been adjusted so that actual printing times do not vary a great deal. Approximate exposure times are:

Contact (Gaslight) ...	5 Secs.	12	ins.	from	40	watt	lamp
Bromide	4 ,,	48	,,	,,	25	,,	,,
Clorona	8 ,,	24	,,	,,	60	,,	,,

Exposures shorter than 4 seconds should be avoided unless a time switch is being used.

To ascertain the correct exposure, the most convenient and economical technique involves the use of test strips cut from a larger sheet. With all Ilford Bromide Papers, whole plate size and larger, small test sheets are packed.

ENLARGING OR PROJECTION PRINTING

The term enlarging covers the making of prints, which are larger than the original negative, by projection of an enlarged image on to the sensitive paper. In recent years great changes have taken place in the design of enlarging equipment; vertical instruments taking up little bench space and furnished with automatic focussing devices have come into common use, and diffuse light illumination has tended to displace the straightforward condenser type. With bromide and other papers available in a large range of contrasts and of ample speed, enlarging has become the general practice among amateur photographers. In some degree the tendency has been fostered, or even forced, by the increasing popularity of small cameras.

Types of Illumination. It was once common practice to use daylight for the making of enlargements, but now the choice mainly lies between half-watt lamps and mercury vapour tubes, and the amateur will generally consider none but the half-watt type of illumination. The extended source provided by mercury vapour lamps has certain advantages when diffuse lighting is required. Its light is intense; it gives out little heat and is economical in current, but the appearance of the image on the easel is deceptive, and the beginner is very apt to over-expose. Because the mercury vapour spectrum is not continuous it is less efficient with colour sensitive papers, such as Plastika and Multigrade. Even the more modern high-pressure types in which a continuous spectrum is superimposed on the line

spectrum give soft results with Plastika. Mercury light sources are not advised for use with Multigrade.

It is quite possible to build an enlarger using mercury vapour lighting to accommodate all negatives from vest pocket up to 15 in. × 12 in. Fig. 77 shows the general layout of a typical instrument. The illuminant is a Hewittic mercury vapour tube, diffused by one sheet of coarse ground glass fixed inside the light chamber, about 4 in. from the negative. The light chamber is lined with asbestos sheeting. The easel is fitted with box runners on little drawer wheels running in grooves on top of the overhead wooden rails which are fixed to light chambers and the opposite wall, allowing a maximum distance between lens and easel of about 12 feet.

Another type of enlarger used for large negatives employs reflected light from arc lamps, and here again a high degree of diffusion is obtained.

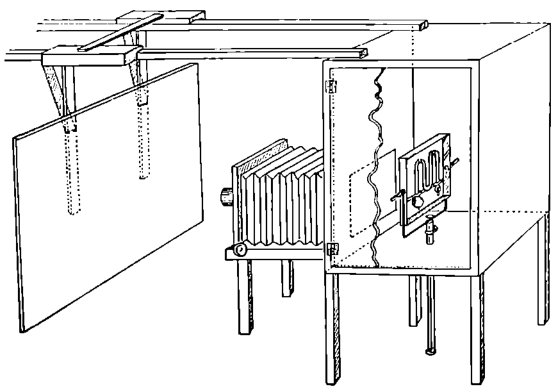


Fig. 77. Mercury-vapour enlarger.

A suitable half-watt lamp provides an efficient source of light for enlarging, and most of the popular enlargers utilize such a source. It may be used in conjunction with a condenser, in which case the results will tend to be contrasty, or with a diffusing system, in which case softer results will be obtained. In the former instance, scratches and retouching marks tend to be accentuated—in the latter case they are subdued. Often a compromise is found and a condenser is used in conjunction with a diffusing screen. For even illumination of the negative to the corners, the diameter of the condenser must be a little greater than the diagonal of the negative, *viz.*, 5½ in. for ¼-plate.

Optics of the Condenser Enlarger

The condenser forms an image of the source S^1 within the projection lens, Fig. 78. If S were a point source, the condenser achromatic

and aplanatic and the negative completely non-scattering, a satisfactory image would be cast upon the easel, even in the absence of the lens L, and even with such a lens, its quality would not affect the result.

In practice, of course, these conditions do not apply. The light source is not a point, and the condenser is never aplanatic or achromatic, and so there is no point of focus of the converging rays from the condenser. For this reason the negative NG is considered as a secondary source, and the lens L employed to form an image of this source in the plane of the easel. The negative image effects some scattering of the light, so that a cone of light spreads out from each image point, filling the lens L—but very unequally. Under these conditions, a poor lens definitely affects the quality of the image. Stopping down slightly may improve definition but soon limits the field of even illumination. The focal length of L should not be too short, because if big enlargements are required, it would be necessary for the light source to be a long way from the condenser. This would require a big lamphouse, and again might limit the area of the negative illuminated. A lens of very long focal length means, of course, a long throw from lens to easel to obtain a big enlargement.

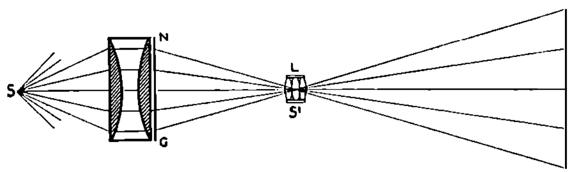


Fig. 78. Optics of condenser enlarger.

The best advice (Clerc) is to choose a lens whose focal length is at least equal to that of the condenser, but which does not exceed it by more than 30 per cent.

The condenser should be chosen in relation to the maximum size negative which will be used. Its diameter should be at least equal to the diagonal of the negative, and its focal length about three-quarters of that value.

Arrangement of the Light Source. There is an optimum position for the light source for every degree of enlargement. In other words, whatever the distance between negative and lens, the light source condenser distance should be adjusted to cause the light beam to converge to its narrowest cross section within the projection lens. First, project the image to the correct size in approximate focus, and then remove the negative and examine the illuminated disc on the easel. If the illumination is even, the light source is correctly placed on the optic axis. If the light is too far away, the patch will have a reddish border—if too near, the border will be blue, and if the light is off centre unsymmetrical shadows are obtained.

The reasons for these effects can easily be understood. Because of chromatic aberration the converging beam from the condenser has a red fringe. After passing through the point of narrowest cross section the diverging beam has a blue fringe. If the position of the source is such that convergence occurs too suddenly, *i.e.*, so that the narrowest cross section is obtained before the lens (lamp too close), the illuminated patch will have the blue fringe. If the narrowest cross section comes after the lens (lamp too far away), the fringe will be red.

Diffuse Light Enlarging with Half-watt Lamps. It is easy to convert a condenser enlarger to give diffuse light illumination by placing the source close to the focus of the condenser and incorporating a diffusing screen between condenser and negative. The presence of the condenser is not, of course, essential—for small negatives an opal bulb gives uniform illumination. For larger negatives one may use an assembly of such bulbs—a bulb silvered at the tip, or a diffuser specially treated so that the transmission of the central part is reduced.

Negative Carriers. Enlargers are fitted with a "nest" of carriers to hold negatives of various sizes, from the largest the apparatus will take to the smaller sizes. Special carriers are usually provided for film negatives or alternatively they may be sandwiched between two pieces of thin but good quality glass, which must be kept scrupulously clean. Carriers supplied with vertical enlargers are usually quite satisfactory, but those on the cheaper patterns of condenser apparatus are frequently fitted with turn-buttons, which do not hold the negative firmly against the rebate of the carrier. A spring of the "mouse-trap" pattern can be fitted, and is necessary if negatives are loose when in the carrier.

Easels and Paper Holders. With a horizontal enlarger the sensitive paper is pinned to an easel which must be parallel to the negative, and if the easel is not larger than the largest paper in use its centre should be on the lens axis. For enlargements with white margins it is necessary to fit to the easel a masking device which may take the form of a hinged metal mask, or a cardboard device such as described on page 304. For vertical enlargers special paper-holding and masking devices can be obtained commercially, but with the better class vertical enlargers this fitting is a part of the apparatus. It is placed on the bench or bed-plate under the apparatus. The cardboard device already mentioned can be used equally well with the vertical enlarger, and is simply laid on the horizontal easel.

The Negative. Now that bromide papers can be obtained in such a wide variety of contrasts, and even more particularly since the introduction of special papers having variable contrast, good

enlargements may be made from negatives of a wide range of gradation or quality. The choice of type and contrast of sensitive paper in relation to negative is fully dealt with in the chapter on development papers, and what is said there applies equally well to enlargements. There is, however, one type of negative which is difficult to enlarge, *viz.*, the very dense over-developed negative or one which has a deep yellow-stained image. Such negatives should

DISTANCES WHEN ENLARGING AND REDUCING

Focal length of Lens	Degrees of Enlargement							
	1	2	3	4	5	6	7	8
ins. 3	ins. 6 6	ins. 9 4 1/2	ins. 12 4	ins. 15 3 3/4	ins. 18 3 3/5	ins. 21 3 1/2	ins. 24 3 3/7	ins. 27 3 3/8
3 1/2	7 7	10 1/2 5 1/4	14 4 2/3	17 1/2 4 3/8	21 4 1/5	24 1/2 4 1/12	28 4	31 1/2 3 15/16
4	8 8	12 6	16 5 1/3	20 5	24 4 4/5	28 4 2/3	32 4 1/7	36 4 1/2
4 1/2	9 9	13 1/2 6 3/4	18 6	22 1/2 5 5/8	27 5 2/5	31 1/2 5 1/4	36 5 1/7	40 1/2 5 1/16
5	10 10	15 7 1/2	20 6 2/3	25 6 1/4	30 6	35 5 5/6	40 5 5/7	45 5 5/8
6	12 12	18 9	24 8	30 7 1/2	36 7 1/5	42 7	48 6 6/7	54 6 3/4
7	14 14	21 10 1/2	28 9 1/3	35 8 3/4	42 8 2/5	49 8 1/6	56 8	63 7 7/8
8	16 16	24 12	32 10 2/3	40 10	48 9 3/5	56 9 1/3	64 9 1/7	72 9
9	18 18	27 13 1/2	36 12	45 11 1/4	54 10 4/5	63 10 1/2	72 10 2/7	81 10 1/8
10	20 20	30 15	40 13 1/3	50 12 1/2	60 12	70 11 2/3	80 11 3/7	90 11 1/4

The table is used as follows:—Knowing the focal length of the lens to be used and the degree of (linear) enlargement, look up the figure for enlargement in the upper horizontal row, and carry the eye down the column below it until it reaches the horizontal line of figures opposite the focal length of lens in the left-hand column.

When *enlarging* the greater of the two distances where the two lines join is the distance from the lens to the sensitive paper or plate; the shorter is the distance from lens to negative, or picture being enlarged direct.

NOTE.—When *reducing*, the distances are reversed; the greater the distance from lens to original, the smaller that from lens to sensitive plate.

be chemically treated to make them suitable for enlarging. The dense negative can be reduced as directed in the chapter on after-treatment. The yellow-stained negative may be cleared by placing it in a 5 per cent. solution of hydrochloric acid for a few minutes or treated by the permanganate bleach method (p. 459).

Preparing the Negative. The negative should be very carefully spotted to remove all transparent spots and defects, as described in Chapter XII. In making enlargements over 3 diameters the effect of careless spotting will be very apparent.

It is best to use the non-condenser type of enlarger when there is much handwork on the negative, but it is well to remember that handwork which will pass unnoticed on a contact print may be very objectionable in an enlargement even when it is made with a diffuse light enlarger. Handwork should never be used to increase the density of any part of the negative if the desired effect can be obtained by local shielding during the making of the print.

Exposures in Enlarging. There are many factors which affect the exposure in enlarging, *viz.*, the illuminant, the aperture of enlarging lens, degree of enlargement, density and colour of the negative, speed of the sensitive paper, and the effect desired. Various types of photometer have been devised to assist in the determination of exposure but the beginner is advised to rely largely upon trial, and for this purpose a sheet of the sensitive paper to be used is cut into strips and used for test exposures. These can conveniently be made by means of the Ilford Test Strip Holder (Fig. 79). Although no reliable data can be given as to correct exposure, we can offer as a rough guide an instance in ordinary work, *viz.*:—Vertical enlarger with two 50-watt electric lamps diffused through one flashed opal glass; negative of average density, enlargement of 3 diameters; enlarging lens at $f/5{\cdot}6$, on Ilford Normal Bromide Paper, exposure, 15 seconds.

ILFORD TEST STRIP HOLDER

The Ilford Test Strip Holder is designed to assist in the determination of correct exposure during enlarging. In the normal way a strip of bromide paper is uncovered in sections so that adjacent portions of the strip receive different total exposures and on the basis of these results the final exposure is decided upon. The Ilford Test Strip Holder provides a simple means of obtaining four different single exposures side by side **from the same portion of the negative** and thus presents a very definite advantage. The holder consists essentially of a metal mask with a printing aperture beneath which successive portions of the paper may be exposed for any exact time desired.

Instructions:

First cut strips of the paper to be used about 3¼ in. long × 1 in. wide (a ¼-pl. sample piece such as is included in all packets of

Ilford Bromide Paper sizes 1/1-pl. to 12 × 10 in. inclusive gives four such strips). With a safety filter on the lens fix the Test Strip Holder in position on the enlarging table or easel with the open square over the selected part of the picture. It is usually best to select an area containing the heaviest negative density which it is desired just to print through. The holder may conveniently be held in position by glass-headed push pins through the three corner holes. A strip of bromide paper is now slipped into the test holder from the open side so that it butts up against the closed end and side. The safety cap is removed and the first exposure is made. The paper is now slid lengthwise down to the first notch and a second somewhat longer exposure is made with the paper in this position. The paper

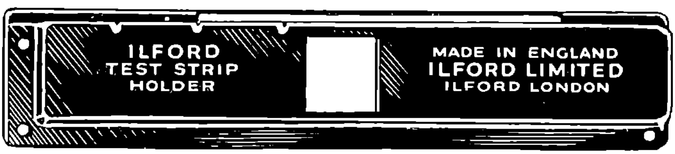


Fig. 79. Ilford Test Strip Holder.

is slid down in this way to each successive notch, a different exposure being given to each area. The strip is then developed in the standard developer for the standard time and after a visual comparison of the four results the best exposure can easily be judged.

Strips of the indicated size extend outwards from the strip holder by an amount which is sufficient to permit their being gripped by a small paper-fastener or other device by means of which the paper can be moved with certainty into different positions. Another very simple method is to move the paper by inserting the point of a pin at the top edge of the aperture near the closed side of the holder and drawing the strip lengthwise across the aperture by means of it.

Standardization of Technique

To obtain successful enlargements the reader is advised to do all he can to standardize as many as possible of the factors affecting exposure. Much may be done in this respect, *viz.*:—

Illuminant. It may be thought that the use of a lamp of a particular wattage ensures a constant light, but commercial lamps are sometimes found to vary considerably from their marked wattage, and this output may vary with age. Moreover, voltage fluctuations occur, especially where the user of current is on the edge of the district of supply. The intensity of the illumination at the copy board may be measured by means of a photometer, but, generally speaking, the Test Strip method outlined above guards against all but voltage changes in the supply line occurring actually during the course of the work. It should be noted that the mercury lamp does

not reach its full intensity until about three minutes after lighting, and should not be used until after that period.

Lens Aperture. There should not be any necessity to stop down if the lens is an anastigmat giving a flat field. It may be done when the correct exposure would be too short to allow of any local control, but as a general rule it is not advisable to use a smaller stop. It should be borne in mind that the customary rule of twice the exposure when using the next smaller stop does not apply to the lens of the condenser enlarger.

Degree of Enlargement. Having once ascertained the exposure with one particular negative for an enlargement of a given size, the exposures for other sizes from the same negative can be obtained from the table below reprinted from the *British Journal Almanac* 1935.

Quality of the Negative. The density, colour, and contrast of negatives can be more or less standardized by giving correct exposures when taking the negatives, and by using a standard developer and timed development.

RELATIVE EXPOSURES WHEN ENLARGING WITHOUT A CONDENSER

New times of enlargement	Time of enlargement for which exposure is known											
	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	5	6	8	10	12
1	1	$\frac{2}{3}$	$\frac{2}{5}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{5}$	$\frac{1}{6}$	$\frac{1}{9}$	$\frac{1}{12}$	$\frac{1}{20}$	$\frac{1}{30}$	$\frac{1}{40}$
$1\frac{1}{2}$	$1\frac{1}{2}$	1	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{2}{5}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{1}{12}$	$\frac{1}{20}$	$\frac{1}{30}$
2	$2\frac{1}{4}$	$1\frac{1}{2}$	1	$\frac{3}{4}$	$\frac{3}{5}$	$\frac{2}{5}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	$\frac{1}{9}$	$\frac{1}{12}$	$\frac{1}{20}$
$2\frac{1}{2}$	3	2	$1\frac{1}{4}$	1	$\frac{3}{4}$	$\frac{3}{5}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{1}{10}$	$\frac{1}{15}$
3	4	$2\frac{1}{2}$	$1\frac{4}{5}$	$1\frac{1}{4}$	1	$\frac{3}{4}$	$\frac{2}{3}$	$\frac{2}{5}$	$\frac{1}{3}$	$\frac{1}{5}$	$\frac{1}{8}$	$\frac{1}{11}$
$3\frac{1}{2}$	5	$3\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{1}{4}$	1	$\frac{4}{5}$	$\frac{1}{2}$	$\frac{2}{5}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{1}{9}$
4	6	4	3	2	$1\frac{1}{2}$	$1\frac{1}{4}$	1	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{5}$	$\frac{1}{7}$
5	9	6	4	3	$2\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{1}{2}$	1	$\frac{3}{4}$	$\frac{2}{5}$	$\frac{1}{3}$	$\frac{1}{5}$
6	12	8	5	4	3	$2\frac{1}{2}$	2	$1\frac{1}{4}$	1	$\frac{3}{5}$	$\frac{2}{5}$	$\frac{2}{7}$
8	20	13	9	7	5	4	$3\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{3}{4}$	1	$\frac{2}{3}$	$\frac{1}{2}$
10	30	19	13	10	7	6	5	$3\frac{1}{2}$	$2\frac{1}{2}$	$1\frac{1}{2}$	1	$\frac{3}{4}$
12	42	27	19	14	11	8	7	$4\frac{1}{2}$	$3\frac{1}{2}$	2	$1\frac{1}{2}$	1

To use this table find in the top horizontal line the number of times of enlargement for which exposure is known. Under this number the relative time of exposure for different degrees of enlargement will be found opposite the new times of enlargement in first vertical column.

Speed of Paper. The speed of the enlarging paper will be fairly constant provided paper of the same make, surface, and grade is used, and the same procedure of development, etc., carried out.

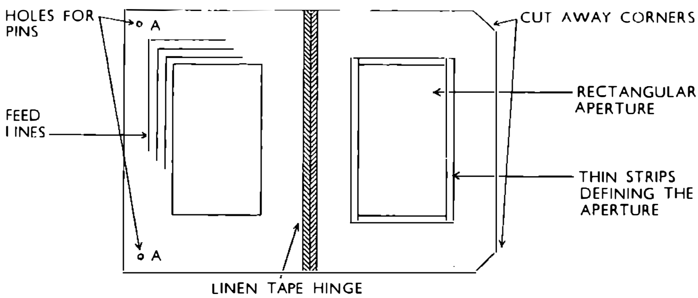


Fig. 80. Cardboard masking device for enlargements.

Mask for White Margins. Convenient masking devices to facilitate the production of enlargements with white margins are easily made and one of the simplest and best types is illustrated in Fig. 80. It will be seen that the device consists of two pieces of cardboard hinged together with linen tape. From one of these is cut a rectangular area corresponding in dimensions to the image size required. This board constitutes the mask, and in practice the device is used "bookwise" with the mask on top. To enable the "book" to be opened easily when it is in position on the easel the outer corners of the mask are cut away. The second board has a sheet of white paper stuck down to the surface facing the mask, and on this paper surface feed lines are drawn as shown to ensure that when different sized sheets of printing paper are placcd upon the board they will be symmetrically situated with regard to the masking card. The card bearing the white paper and feed lines may conveniently be attached to the device by drawing pins shown at A, A. In practice the focussing card is placed in position and the book closed and when focussing has been completcd the book is reopened, the printing paper substituted for the card and the mask brought down again to hold the paper securely in the desired position while the exposure is made.

As stated, the boards from which the device is constructed should be stout, and it may be found rather a difficult matter to cut out the rectangular area accurately, leaving good clean edges. In this case the best plan is to cut the rectangle rather larger than required, reconstituting the smaller area again by strips of thin card gummed in position on the side of the mask facing the printing paper. A further refinement which can be incorporated when only one size of paper is to be used involves replacing the feed lines by a small corner piece under which one corner of the paper may be slipped, and by

means of which the paper is accurately held in position. The corner piece must, of course, be so small that it does not encroach upon the image area.

Control in Enlarging. Enlarging gives the worker the opportunity of controlling the picture by intercepting the projected image between the lens and the easel. It is no exaggeration to state that a "straight" enlargement from any negative is seldom the best that can be obtained and with the great majority of subjects—landscapes, portraits, architecture or technical—a little local shielding of parts which print too deeply, or the "burning out" of detail in some especially dense part of the negative, will work wonders. By "burning out" is meant the giving of longer exposure (by shading all the rest) to parts of the paper where the images of dense highlights fall.

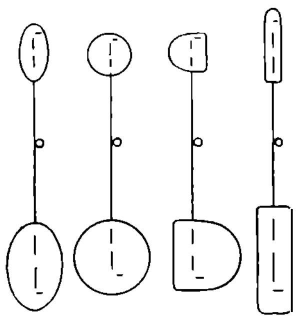


Fig. 81. Shields for local control in enlarging.

Control of this kind may be used to compensate for uneven lighting of the subject or to give added prominence to any given part of the composition.

In many photographs of groups, the front row or the foreground prints too deeply in a "straight" enlargement. Such a subject will be greatly improved by shielding that portion during part of the exposure, using a piece of strawboard at about 4 in. from the easel and keeping the shield moving slightly. A portrait in which the shadow side of the face becomes too dark before the full details of the other parts are out can be improved by using one of the shields on wire shown in Fig. 81. To bring out detail in a dense part, all that is required is a large piece of strawboard from which has been cut or torn a hole slightly smaller than the part to be treated. After exposing the whole picture in the usual way, the strawboard is brought into action to shield all parts except that which it is desired to expose further. The shield is held fairly close to the easel and kept on the move slightly for such an additional time as can only be ascertained by a test or trial enlargement.

The wired shields are made from thin strawboard cut to a variety

of shapes and sizes, a few of which are illustrated. Thin stiff wire is threaded through holes in the strawboard, and the shields are double-ended. The central twist in the wire is for hanging on a nail in the darkroom. An endless variety of shapes and sizes are obtained by tilting, using at different angles and at different distances from the easel. Skilled enlargers use their hands and fingers for local control, but when some central part of the image has to be shielded the wired shields are preferable.

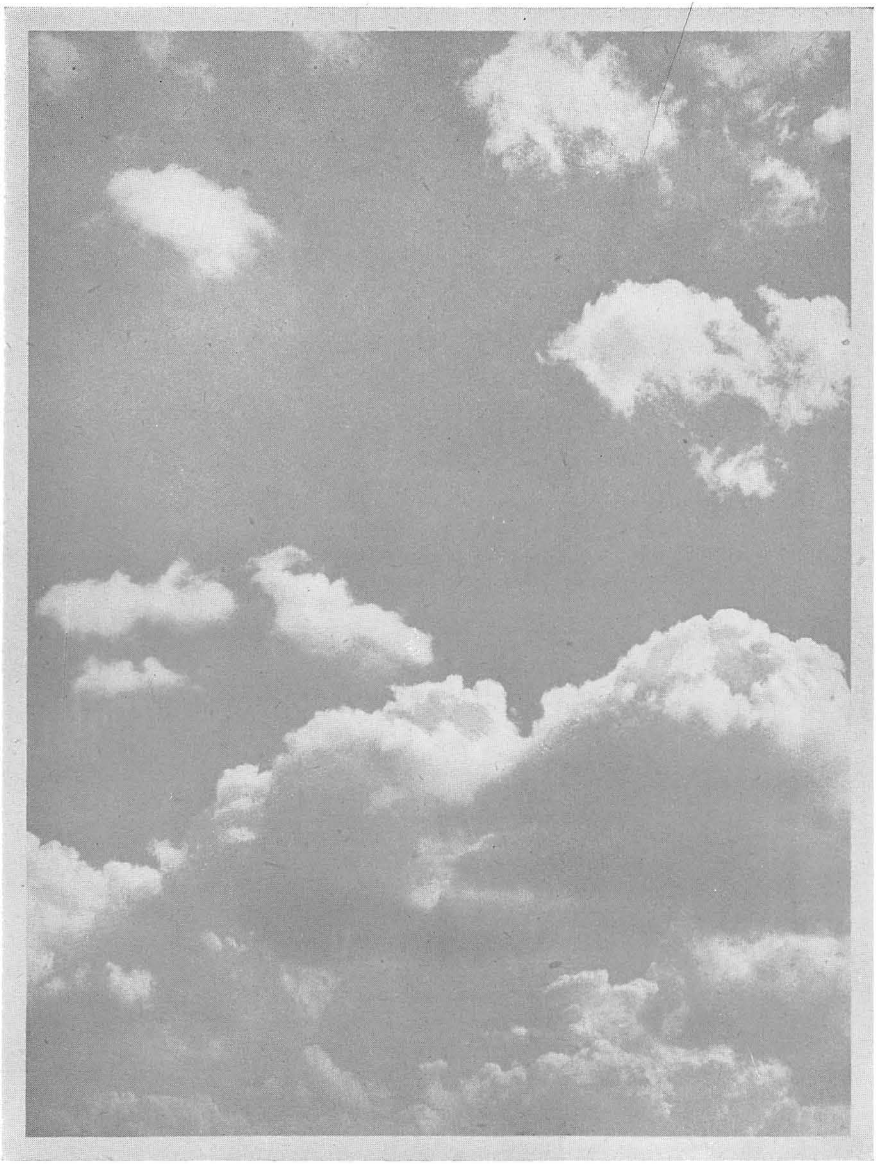
Soft-focus Enlargements. Subjects of a pictorial nature are often greatly improved by diffusing the image so as to blur its aggressively sharp definition slightly by giving it a soft appearance, with a slight overlapping of the edges of the shadows. It is not sufficient merely to throw the enlargement out of focus, as this would give a result far from pleasing. The image must be broken up by the interposition of some net-like material between the lens and the picture. A piece of black or dark chiffon, bolting silk or fine-mesh wire can be fitted to a rim which is slipped on to the enlarging lens during part or all of the time of exposure. In addition to giving a diffused image, the enlargement also shows slightly weaker contrasts. Net-like material may be also stretched over a card cut-out and used close to the easel or in contact with the enlarging paper. The texture effect is then usually more pronounced.

Vignettes. To vignette an enlargement means to "fade-out" the edges of the picture so that they merge gradually into the background and have an irregular but soft edge. This is done by interposing between the lens and the easel a sheet of cardboard from which has been cut an oval, circle, or other suitable shape a trifle smaller than the vignette is required to be. The edges of the aperture may be serrated. This vignetting card is held in the hand at about 4 to 6 in. from the easel and slightly rotated or moved backward and forward. Vignettes are only suitable for certain subjects such as portraits with light backgrounds, but by local blocking out on the negative, combined with vignetting, a clever worker can produce artistic and "sketchy" effects with landscape and other subjects. Another method of vignetting is to clean off or locally reduce the background or edges chemically by the iodine-cyanide reducer described on page 274.

Adding Clouds or Skies. When there are no cloud forms in a landscape or seascape enlargement they can be inserted from a separate cloud negative, giving one exposure for the landscape and another for the clouds on the same piece of bromide paper. The yellow cap of the enlarging lens allows the bromide paper to be suitably placed. It is not necessary to discuss the artistic side of cloud printing except to mention that the lighting of the clouds should be in the same direction as the landscape.

When the sky line of the landscape is fairly straight the clouds can

No. 1. Picture without clouds.



No. 2. Clouds enlarged from separate negative.

No. 3. Picture with clouds added.

be inserted quite easily, but when there are objects protruding into the sky the work is more difficult and calls for some manipulative skill. Trees or dark objects can often be ignored, and the clouds exposed over these parts, but when the objects are light in tone special shielding masks are necessary.

Having chosen the most suitable cloud negative for the picture, examine the landscape negative to see if it is necessary to block out or shield the blank sky part. Such opacity or shielding is absolutely necessary for a thin negative, otherwise the sky may transmit some light when exposing the landscape enlargement, causing a grey tint over the sky which will degrade the all-important highlights of cloud forms. The landscape negative is then placed in the enlarger, the image focussed to size on the easel, and after a preliminary test for exposure (using a small strip of the bromide paper) a "straight" enlargement is made, developed, fixed, roughly washed, and dried. Before removing the rough enlargement, marks should be made on the easel to act as a guide for the correct placing of the second landscape enlargement which will include the clouds. The next step is to expose, but not develop, another enlargement from the same negative correcting any errors in exposure or shielding parts which appear too dark in the first enlargement. When exposed, and before the paper is removed from the easel, place the usual yellow cap on the lens, and with a black pencil make a short heavy line on each side of the picture where the horizon comes, and indicate by a small arrow the top of the picture. The exposed paper is then removed from the easel and placed in a light-tight box or wrapped in black paper out of harm's way whilst the landscape negative is being removed and replaced by the cloud negative. The first rough enlargement is then placed on the easel, adjusted to suit the position of the cloud, and the image focussed upon the blank sky part of the enlargement.

After removing the rough enlargement, make a strip test exposure for the clouds, and when the correct exposure has been ascertained the exposed landscape enlargement can be placed in position on the easel and the clouds exposed. Guided by the horizon black marks on the paper, shield the lower part by holding a piece of cardboard about 3 in. from the easel, and keep it moving slightly up and down to give a soft edge. If the clouds near the horizon print too deeply in proportion to the other clouds, they can be shielded for a little longer time by raising the cardboard. This cardboard shield can be cut to the contours of the horizon if necessary. The clouds should merge imperceptibly into the landscape, and during exposure it is advisable to hold the shield, momentarily, a little lower than the horizon marks. (See illustrations on pages 307, 308, and 309.)

For exhibition enlargements, or when the sky line is very intricate, it may be best to make a reproduced enlarged negative *via* two transparencies, as described on page 311.

Developing and Fixing of Large Prints. When making enlargements of very large size there is the question of large dishes or trays. In cases where very big enlargements are only occasionally made the dishes need only be a few inches larger than the narrow way of the enlargement, since the operations can be carried out by festooning or drawing the paper up and down in the same manner as when developing a roll film in a small dish. In exceptional cases development can be carried out by placing the enlargement face up on a flat surface and rapidly applying the developer all over the enlargement with a large sponge or swab. Fixing can be done in the same way. Makeshift trays can be made from large pieces of cardboard by turning up the edges, clipping the corners of the overlapping edges, and coating the inside with paraffin wax.

Enlarged Negatives. An alternative method of producing enlargements is to make an enlarged negative from the original small negative and to print by contact. If a very large number of enlargements is required from one negative this is the best and cheapest method. It also enables one to make large prints on the slower types of printing papers.

There are two methods available, *viz.*, one may make an enlarged negative by copying a paper print or enlargement, or a large negative *via* a positive transparency. In the first method an enlargement is made from the original negative on glossy or smooth bromide paper, mounted on smooth card, worked up or retouched where necessary, and a new negative made from this enlargement by copying in the camera on a plate of the required size. This method usually results in a reproduction which is not quite true to the original or is slightly degraded in its highlights. There may also be some granularity of the image. The degraded lights can be restored by handwork on the negative, and the granularity will not be so pronounced if the enlarged negatives are printed on rough-surfaced papers.

The second method is to make a transparency by contact or enlargement on a plate of suitable contrast, and from this positive transparency to make an enlarged negative of the size required. This is undoubtedly the best method of reproduction, and if the work is properly carried out it is often difficult to tell that the enlarged negative is a reproduction.

The Positive Transparency. The transparency can be made by placing a plate (a slow plate such as the Ilford Ordinary), film side in contact with the film side of the original negative, exposing it for about 4 to 10 seconds to the light of one candle at a distance of 4 feet. A backed plate should be used. This exposure is given only as a rough guide and is for a good average negative. Those who possess an enlarging camera are advised to make the transparency by projection. The lens image can be sharper than the contact print,

and one stage towards the enlarging can be done by making, where possible, an enlarged transparency. It must not be made larger than the largest size the enlarger carrier will take, although it may sometimes be an advantage to make a full-size transparency, and from that make a negative by contact. This method is useful when much spotting or handwork has to be done because of a defective original negative.

The kind of plate to use for the transparency or the negative depends upon the quality of the original or the effect desired.

The Ilford Special Rapid Plate is one of the finest plates available for transparencies and enlarged negatives, and will give a faithful reproduction of all the gradations in the original, and can also be used to soften harsh contrasts.

If increased contrast is required the transparency should be made on an Ilford Ordinary Plate and if still more contrast is required the enlarged negative is made on the same plate. Alternatively, Fine Grain Ordinary Film may be used. When dealing with an abnormally flat, poor, original negative, it is possible to obtain an extraordinarily contrasty reproduction by using an Ilford Process Plate, Special Lantern Plate or Diapositive Film.

In making the transparency it is extremely important so to expose as to get all the detail with a fair amount of density. When the negative is placed in contact with a piece of white paper there should be no clear-glass portions excepting the rebate. The kind of transparency used as a lantern slide is *not* suitable. It should appear to be distinctly flat in contrast, with full detail visible when looked through.

Before making the enlarged negative the transparency must be spotted or retouched, and if the rebates or edges show clear glass they must be blocked out or masked; otherwise the volume of white light will fog, by irradiation, the edges of the negative. The procedure of making the negative is the same as that of making the transparency.

Clouds in Enlarged Negatives. In introducing clouds (from a separate negative) into an enlarged negative, two separate transparencies are made, one from the landscape and one from the clouds, and bound together. This composite transparency is placed in the enlarger and a new negative made by projection on a plate of suitable contrast. The landscape transparency is made in the usual way, but the blank sky part must be blocked out on the negative, or shielded during exposure, or chemically reduced out on the transparency. When making the cloud transparency the lower part of the clouds is shielded, or can be chemically reduced.

CHAPTER XV

OTHER PRINTING PROCESSES

●

Platinum Printing. Although materials for this process are not now available, the following details are included for completeness and historical interest.

Platinotype is a process of iron printing in which paper is sensitized with a mixture of ferric oxalate and a platinum salt. On exposure to light the ferric oxalate is converted into ferrous oxalate, which has the property of reducing a platinum salt to metallic platinum. Ferrous oxalate, however, is practically insoluble in water, and thus an exposed print must be placed in a solution which dissolves ferrous oxalate in order that the latter may act on the platinum salt. A strong solution of potassium oxalate is used for this purpose and is called the "developer," although its action is chemically different from that of other developers described in this book. Its action is to bring the ferrous oxalate (which forms a semi-visible image on the paper) into solution, whereupon platinum metal is deposited in proportion to the amount of ferrous oxalate present at each point in the print. The picture is thus formed of full depth in a few seconds, and all that remains to be done is to remove the excess of iron and platinum salts by passing the print through several baths of dilute hydrochloric acid.

Platinotype paper had to be kept perfectly dry before use, and so was supplied in sealed tins containing dried calcium chloride, held in asbestos, which is a powerful absorbent of moisture. It was about three times as sensitive as P.O.P., and care had to be exercised to prevent light fog. It could, however, be handled in subdued white light.

There was a second variety of platinum paper which gave sepia tones; a hot developer (about 160°F.) (71°C.) being used. When, as was usual, the sepia tones were produced by the presence of mercury salts in the ferric oxalate mixture, permanence was in some doubt. Similar tones could also be obtained by the use of ordinary platinum paper and a developer containing mercury salts.

Platinum Developer. As described above the main constituent is potassium oxalate to which, preferably, a proportion of potassium biphosphate is added; the solution should be slightly acid, for which purpose a little oxalic acid may be added. A suitable formula is:

Potassium oxalate ..	.. 3 oz.	or	75 g.
Potassium biphosphate	.. 24 gr.		1·2 g.
Oxalic acid	.. 6 gr.		0·25 g.
Water, up to	.. 20 oz.		500 c.c.

After development the prints are cleared by two or three successive treatments with dilute hydrochloric acid (conc. acid, 1 part; water, 60 parts), using a fresh bath for the last treatment, and then thoroughly washed in several changes of water. Careful attention to the clearing operation is necessary for permanence.

Palladiotype is a printing process very similar to Platinotype in principle and results. It differs from the latter in the use of a salt of the metal palladium in the sensitive coating, the image in the finished print thus consisting of palladium in a finely divided state and of warm black colour.

Ferro-prussiate Process. A process of iron-printing is that known as ferro-prussiate, used almost entirely for making the "Blue-prints," *e.g.*, copies of plans, used by engineers. It can be used for taking prints from ordinary negatives, which, however, require to be of ample vigour.

The paper is readily obtainable on the market, or can be made by treating a suitable paper with a mixture of ferric ammonium citrate and potassium ferricyanide. On exposure to light, Prussian Blue is formed, the print merely requiring thorough washing (preferably with a trace of hydrochloric acid in the final bath) to remove the unexposed and residual salts.

The copy from a line original, *e.g.*, an architect's plan, is in white lines on a blue background.

Pellet and Ferro-gallic Papers. In contradistinction to the foregoing, these papers give prints with dark lines (blue and violet-black respectively) on a white ground. In the Pellet process the exposed copy is "developed" with potassium ferrocyanide, which forms Prussian Blue with ferric salt, while in the ferro-gallic process gallic acid is used, giving a violet-black colour with the ferric salt.

Iron-silver Printing Paper. A method of printing with iron salts, which is also used for copying of plans, is similar in principle to platinum paper, but employs silver instead of platinum for formation of the image *via* the ferrous salt. Paper prepared in this way is known as "sepia" or "brown-line," and yields a copy in white lines on a dark brown ground from a tracing. Unlike the blue print, a sepia copy can be used as a negative for making positive copies (brown lines on white ground) on the same paper. The sensitizer for this process consists as a rule of a mixture of ferric ammonium citrate (green), tartaric acid, and silver nitrate, which is applied with brush or sponge. The paper is printed out to full depth and is fixed in a weak solution of hypo. Copies by this process have not the excellent permanence of ferro-prussiate or ferro-gallic prints. Fading is no doubt due to the partial bleaching action of retained traces of iron salts. Moreover, the gradation is very poor in comparison with bromide or gaslight papers, though just about

equal to giving somewhat harsh prints from really vigorous negatives. Nevertheless, the process is utilized from time to time in the form of a solution for sensitizing paper, silk, and other materials. Prints of a kind may be made in this way, but the process is altogether unsuitable for the negatives now made for use with bromide and gaslight papers.

PIGMENT PRINTING PROCESSES

Carbon Printing. The carbon process differs so completely from other methods of printing, and involves such details of manipulation that adequate description of it is beyond the scope of this manual. Moreover, carbon printing, despite its distinctive merits, has been found incompatible with modern ideas of rapid production in consequence of its dependence on daylight or high-power electric light for exposure of the sensitive material.

The outstanding feature of the process is the variety of prints which can be made by the one procedure—variety in the colour of the pictures and in the tint and texture of the paper on which the picture is finally obtained. To this must be added permanence as great as that of the pigments used in making the tissues for the process.

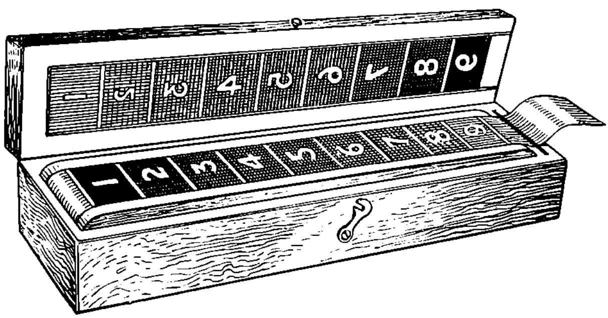


Fig. 82. Actinometer for carbon printing.

This carbon tissue (paper coated with a mixture of gelatin, etc., and pigment) is supplied in a great many colours. It must be rendered sensitive to light with bichromate, which, for amateur use, is best done with a solution of bichromate in spirit. This is brushed over the tissue, which must then be allowed to dry in the dark. It is ready for use in about half an hour.

On exposure to light there is an interaction between the gelatin and the bichromate by which the former is rendered insoluble, the depth to which the insolubilizing is carried depending on the amount of exposure. The effect is not visible, so that an actinometer of the type illustrated in Fig. 82 has to be used for gauging the exposure; P.O.P. is the sensitive material.

Development of the print is done by dissolving away the still

soluble parts with hot water. As the hardening of the film starts at the upper surface, the film must be placed face downward on another support for development. In some cases the developed print (which is now reversed as to right and left) can be used in this condition, in other cases it is necessary to transfer it to a third, final support.

As already stated, the final effect of a carbon print can be varied by the choice of transfer paper of particular tint and surface. The print may likewise be transferred to wood, leather, ivory, glass, and other materials, so that the process lends itself to many applications. Full instructions for its ordinary and special use are given in the publications of the Autotype Co. Ltd., the original and now practically the only makers of tissues and other requisites for the process.

Gum-Bichromate. Little need be said of this process, in which the sensitive material is a coating of gum arabic containing bichromate and a pigment. On exposure through the negative for about 15 minutes in bright daylight, an image is obtained consisting of partially insolubilized gum, with the result that a pigment picture can be obtained by "development" in cold or tepid water. Unlike the gelatin in the carbon process, the gum does not become definitely insoluble by exposure to light, but remains removable to a greater degree by the use of hotter water. Moreover, the pigment is less firmly attached and may be removed mechanically by skilful manipulation with a soft brush or sponge. By these two methods considerable but difficult control can be exercised in making prints, as witness the gum-bichromate prints by Demachy, Puyo, and others, which were a feature of photographic exhibitions about 1900. The introduction of the Oil and Bromoil processes (see Chapter XIX), by which this control is done much more effectively, speedily led to the abandonment of gum-bichromate printing.

Carbro Process. In this variation of the carbon process the carbon print is made from a print or enlargement on bromide paper. In this process, originally introduced as "Ozobrome" and now available in an improved form as "Carbro," the tedious exposure of the tissue to daylight is avoided and instead a bromide print is squeegeed in contact with the carbon tissue after the latter has been soaked for about three minutes in a "sensitizing" bath containing potassium bichromate, ferricyanide and bromide; the bromide print has been previously soaked in a weak formalin solution containing also small quantities of acetic and hydrochloric acids.

The bromide print is left in contact with the "sensitized" and acidified carbon tissue for about 15 minutes, during which time it is partially bleached, whilst the gelatin coating of the tissue is insolubilized to a greater or lesser depth according to the amount of silver deposit present in any particular part of the bromide print.

The action is similar to that produced on carbon tissue when exposed to light under a negative, and appears to be due to the formation of the same chromic compounds which harden the gelatin in the ordinary carbon process.

The bleached print is carefully separated from the carbon tissue, and the latter is then finished as in carbon printing, that is by transfer and development in warm water.

The bromide print is restored to its original black condition after thorough washing, by application of any non-staining developer, and can then be used for making further Carbro prints up to a total of 6 or 12 according to the care with which it is handled. Materials and solutions for this non-daylight form of carbon printing are supplied by the Autotype Co. Ltd., by whom a small handbook on the process is issued.

Diazo Processes. Diazo papers, *e.g.*, Ozalid, Diazo, and Coralin have certain definite advantages for the only purpose for which they are at present made, namely, the production of copies of engineers' and architects' tracings. From these originals they all yield copies in dark lines on an almost white ground. Also the manipulation for the finishing of the exposed prints is exceedingly simple. In the case of Ozalid paper it consists in subjecting the prints to ammonia vapour, so that they remain dry throughout the process and do not suffer the irregular contraction consequent on wetting and drying.

Prints on Diazo and Coralin papers are developed by spraying with a special liquid, and thus are obtained in a dry state within a minute or two. All three papers may be machine-developed by means of appliances designed by the respective makers for treating them with the vapour or liquid. On the other hand, Diazo papers are slower in printing than the fastest ferro-prussiate papers, though considerably more rapid than the ferro-gallic papers hitherto used for the same purpose.

In addition to their use for the duplication of engineers' tracings, Diazo papers have been found to lend themselves excellently to the production of such pieces of commercial "printing" as window bills, showcards, and streamers, which may be quickly and cheaply produced when only a limited number is required. The employment of coloured papers coated with the sensitive "Diazo" preparation has greatly extended the effective use which can be made of these papers for purposes of this kind. By ringing the changes on colour of the paper base and that of the developed image, and also by taking advantage of reproduction in negative or positive form, a great variety of effects is readily obtained by simple means.

THE DEVELOPING AND PRINTING OF AMATEUR FILMS

●

The D. & P. Trade. The developing and printing of roll films and miniature films exposed by amateur photographers now constitutes a considerable business, which by reason of its seasonal nature has many special problems of its own. Because of the general insistence on quick results, speed is essential, and this calls for thorough organization throughout. This applies not only to the photographic operations, but also to the marking, pricing, and sorting of orders. A brief outline of an efficient system is given below.

Order Pads. Each order taken over the counter is entered in a duplicate book and given a number, which accompanies the spool

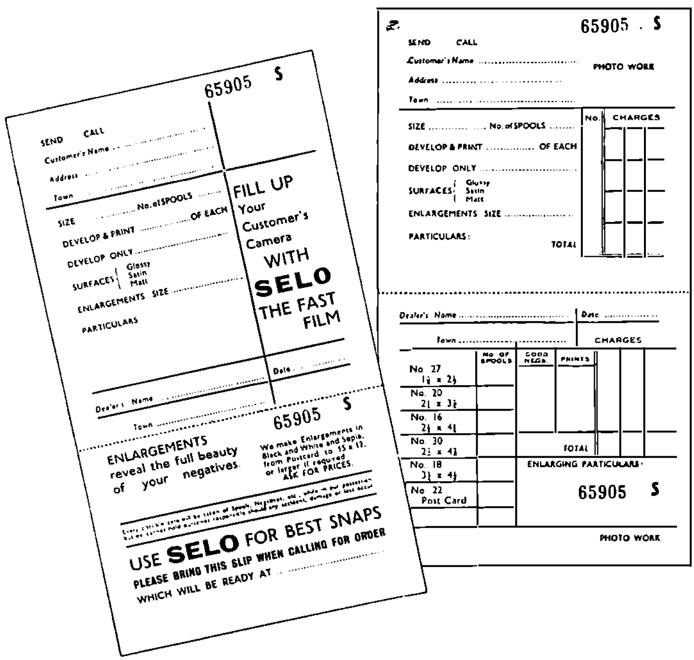
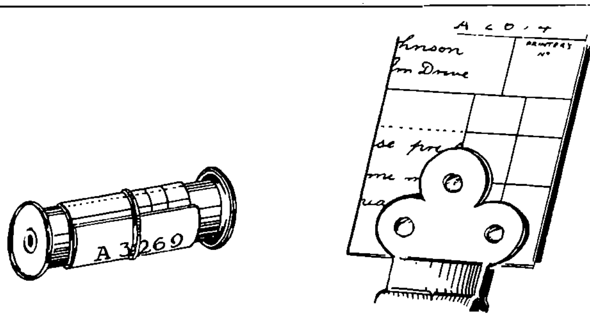


Fig. 83. Specimen D. & P. Order Form.

or spools through all stages until the completed order is returned to the dealer. A specimen order taken from an Ilford D. & P. pad is reproduced half-size in Fig. 83. The order should be wrapped around the spool, as shown in A, Fig. 84, so that the number is

visible to enable any film to be traced easily should any enquiry arise before development. Instructions should be written in the correct places, because, when the film is unspooled for processing the order is inserted in the top portion of a double clip, and if the order has been wrongly completed the instructions may be obscured by the clip itself (see B, Fig. 84). The actual order accompanies the film on all its travels.

Particularly during the peak period of the season, it is highly important that orders should be collected from retailers and deliveries of the negatives made to them on a strict time schedule. Routine collections and deliveries by messengers, on foot, cycle, motor-cycle or car, must be as regular as is humanly possible. Delayed collections upset the works, and late deliveries cause irritation to customers.



A
ORDERS SHOULD BE WRAPPED AROUND FILMS SHOWING NUMBER

B
SHOWING HOW INSTRUCTIONS MAY BE OBSCURED IF THE ORDER IS WRONGLY FILLED

Fig. 84.

Works Lay-out. Wherever possible the principle of straight-line production should be rigorously carried out, material moving constantly from each place to the adjoining one where it is next treated, finally reaching the offices, where it is checked, priced, and despatched. In a works laid out on a U pattern, offices and reception room occupy the space across the ends of the U, whilst in the two limbs are arranged the film developing, washing, and drying rooms, followed by the batching department, printing and developing, washing, glazing, and drying rooms.

Reception. Sacks or bags arriving at the works are emptied into troughs or boxes and the orders checked. Orders for developing, printing from negatives and oddments are separated at this stage and checked; the various orders being easily identified by the

customer's order number. When checked, work is placed in separate boxes—spools for the developing room, negatives for prints for the printing room, and those for enlarging for the enlarging room.

Identifying Films. The maximum ease and certainty in the handling of films is obtained by the use of the double clips already mentioned. The film is attached to the lower part of the double clip, with a weighted clip attached to the lower end of the film. The upper part of the double clip carries the order through every stage of the processing (Fig. 85).

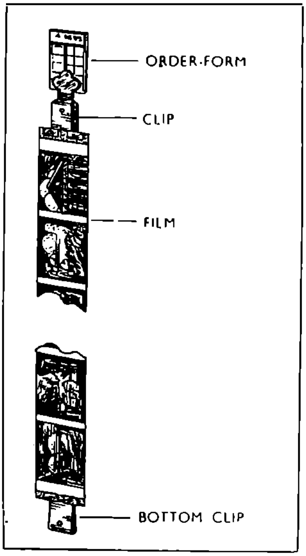


Fig. 85.

Where several spools are sent in on an order from one customer, "link" tickets or cards are employed. The actual order form is attached to the double clip in which one film is placed, whilst another double clip attached to each of the remaining films receives a link card bearing the same number as the order form. By strictly following the unit system, all the films belonging to a particular order may be placed together readily when the dried films are batched.

Developing and Fixing. When unspooled the films are hung, usually three to a rod, the rod passing through a hole in the double clips and hung on brackets until a full tank load has been unspooled. In the larger establishments development is carried out in a separate tankroom, the films being passed through a light-trapped entrance.

The tankroom is shown in Fig. 86, with a batch of films awaiting immersion in the developing tank, which is situated near the entrance. One processing unit consists of six tanks. As the illustration shows, the unit is made up of the developing tank, water tank for rinsing between developing and fixing, first fixing tank, second fixing tank, first washing tank and second washing tank.

Rinsing is employed to remove surplus developer from the films so that the strength of the fixing solution shall be conserved, with the second fixer, usually the fresher, for final fixing. Two successive washings ensure that every trace of hypo is removed from films, clips, and rods.

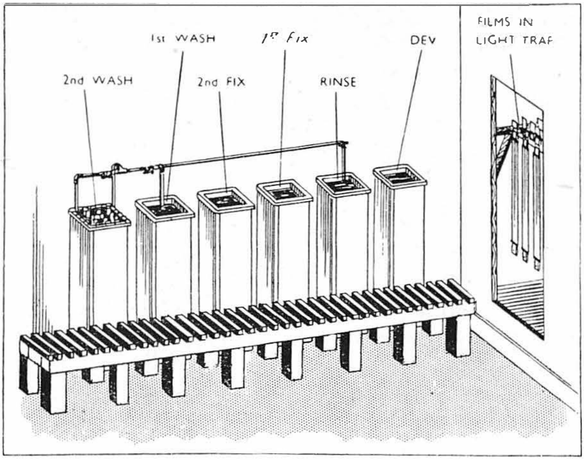


Fig. 86.

With all washing tanks arrangements are made to provide a continuous inflow and outflow. Water enters at the top and runs out through a tap at the base, which is usually kept full on, the flow into the tank being regulated so as to keep the tank full. Some tanks are bored for overflow holes just below the top edges. The tanks may vary in capacity from 10 gallons to 48 gallons, according to the quantity of work involved.

Very large plants have automatic developing units, which involve the use of the "endless chain" for lowering rods into tanks and transferring them from one tank to another. By this method the work is untouched by hand from the unspooling until the films are dry.

Fig. 86 shows a unit of the 10-gallons type of tank, and illustrates how a long platform is provided for the tankroom worker to be at a convenient height for lowering and raising the films.

Special safelight systems are employed nowadays so that panchromatic materials can be handled with perfect freedom from light-fog, although in large works where space permits a special tankroom is set apart for panchromatic films.

Tanks are usually placed either in a lead-lined sink, fitted with a waste-pipe, or in the case of a concrete floor are stood in a shallow gutter which slopes toward the drain-pipe.

Solutions must be kept at an even temperature to get the best results from all negatives, and probably the best method of ensuring this is to bring the room up to the temperature required. Where this cannot be managed, however, electric immersion heaters can be employed in conjunction with thermometers. Special floating thermometers are available for this purpose.

Development times vary according to temperature, and where, for instance, a film may require ten minutes' development at a temperature of 65°F. (18°C.), it may only need nine minutes at a temperature of 67° (19°C.). All films to-day are developed in a modern works by the "time and temperature" method. It is necessary in this plan to see that the strength of the developing solution is kept up to a certain standard, and extra solution in the form of "strengthener" is used for this purpose. This also has the effect of keeping up the level of the solution in the tank, which is constantly being lowered by the removal of liquid carried away on the batches of films. The best replenishing system involves the periodical removal of a certain quantity of developer from the tank and its replacement with "strengthener."

The developer is supplied in powder form ready for dissolving, in packages to make 10 and 12 gallons, including strengthener.

Film Developers. Various development formulæ are available for D. & P., but the one in almost general use at the present time contains metol, pyro, and hydroquinone.

P.M.Q. D. & P. DEVELOPER ID-6

Metol	1 oz.	or	25 g.
Sodium sulphite	1¾ lb.		700 g.
Sodium bisulphite	1 lb.		400 g.
Hydroquinone	5½ oz.		135 g.
Pyro	1 oz.		25 g.
Sodium carbonate (cryst.)	5 lb.		2000 g.
Potassium bromide	50 gr.		2 g.
Water, up to	10 gall.		40 l.

Dissolve the chemicals in the order given in about seven gallons of warm water and make up to ten gallons with cold water.

The developer should be kept up to bulk by the addition, as required, of the strengthener diluted with an equal bulk of water.

STRENGTHENER

Metol	½ oz.	or	12·5 g.
Sodium sulphite (cryst.) ..	½ lb.		200 g.
Sodium bisulphite ..	¼ lb.		100 g.
Hydroquinone	1½ oz.		37·5 g.
Sodium carbonate (cryst.)	1½ lb.		600 g.
Water, up to	1 gall.		4 l.

M.-Q. D. & P. DEVELOPER ID-34

A satisfactory formula similar to the above but omitting the pyro is as follows:—

Metol	1 oz.	or	25 g.
Sodium sulphite (cryst.) ..	2 lb.		800 g.
Sodium bisulphite ..	4 oz.		100 g.
Hydroquinone	5 oz.		125 g.
Sodium carbonate (cryst.)	2½ lb.		1000 g.
Potassium bromide ..	½ oz.		12·5 g.
Water, up to	10 gall.		40 l.

STRENGTHENER

Metol	½ oz.	or	12·5 g.
Sodium sulphite (cryst.) ..	6¼ oz.		156 g.
Sodium bisulphite ..	¾ oz.		18·5 g.
Hydroquinone	½ oz.		12·5 g.
Sodium carbonate (cryst.)	½ lb.		200 g.
Water, up to	1 gall.		4 l.

Fixing. Fixing is of great importance. An acid-hardening bath should be used, and a suitable formula is given below. It has the merit of long life and is thus particularly suitable for D. & P. work:

Hypo	16 lb.	or	8 k.
Stock acid-hardening solution ..	1 gall.		5 l.
Water, up to	8 gall.		40 l.

The formula for the stock acid-hardening solution is:—

Sodium sulphite (cryst.)	8 oz.	or	200 g.
Glacial acetic acid	6 oz.		150 c.c.
Potash alum (powdered)..	8 oz.		200 g.
Water, up to	80 oz.		2 l.

Note.—Exhausted hypo solutions may be sent to refiners who specialize in silver recovery.

Dissolve the sulphite in 16 oz. (400 c.c.) of warm water and allow to cool. Then add the acetic acid slowly, stirring all the time.

Dissolve the alum in 48 oz. (1200 c.c.) of hot water, allow to cool and then add to the acid sulphite mixture.

Care must be taken that all mixing be done at a temperature below 70°F. (21°C.).

Washing and Drying. As we have seen, at least two tanks should be used for washing; if good clean films are to be obtained, washing must be thorough. Each batch of films should remain in running water for at least 10 to 15 minutes. The batch of films, having been removed from the last washing tank, should be drained for a few minutes or squeegeed between fingers or between sticks covered with sponge cloth or towelling, preparatory to drying.

There are on the market various forms of drying cabinets which can be successfully employed, but probably a drying tunnel (Fig. 87) is preferable, at least for larger installations. This should consist of a long room or cupboard with a hot-air inlet at the bottom and exhaust fans drawing off the air from the top. If practicable, the

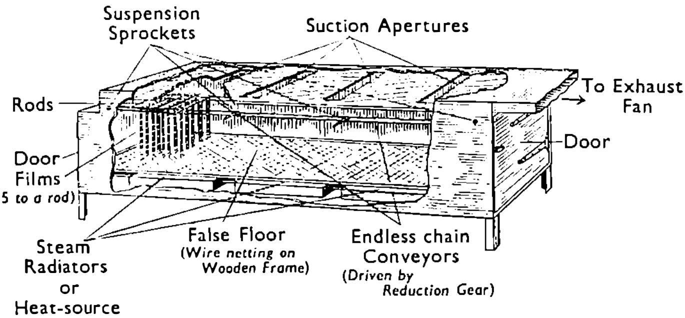


Fig. 87. Drying tunnel.

films should be carried across the room by a conveyer. The dried films are finally divided into batches and sent into the printing room. The double clips are, of course, still on the spools with the order sheets attached.

PRINTING

When films are dry the lower clips are removed and sent back to the unspooling room, and the work is divided into batches of about eight for which film-boxes are used; one is shown in Fig. 88. There are, of course, other forms which the box may take, but this is a convenient design because when the clips are slipped over the "rod" shown, the order forms protrude through the back of the box. If a dealer makes an enquiry regarding a certain order while it is in process of printing, or waiting to be printed, the order numbers can be consulted and the order quickly found, without the trouble of removing the films from the boxes.

In the printing department the boxes are placed on a shelf until wanted. In the larger plants they are conveyed there by means of overhead "railway" systems, so that walking and carrying are reduced to a minimum; the system is also used to take the boxes to the cutting department later on.

Contact prints are almost always made on gaslight paper which as described on page 265 can be handled in bright yellow light, or even in a room which is lighted by ordinary half-watt light, provided that only small-powered bulbs are used and that the light is not allowed to fall directly on to the paper. A common practice is to cause the light to be reflected from white walls or the ceiling.

Up-to-date finishers have installed one or other of the various "automatic" printing machines. These are expensive but they permit of print-exposing by quite inexperienced operators—and when it is realized that this process is one calling for the highest skill in photo-finishing it will be readily appreciated how useful such machines really are.

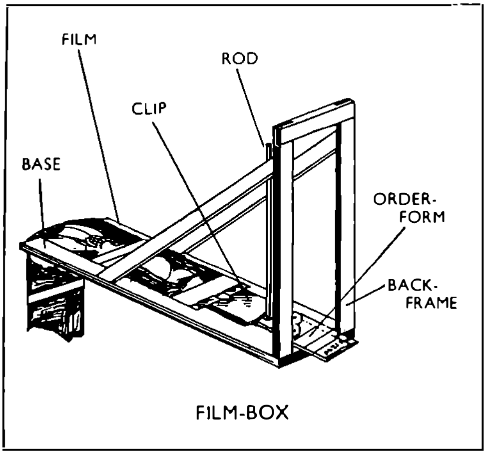


Fig. 88.

In general the machines measure the average density of the negative by means of a photo-electric cell. One popular type makes use of a visual measurement of densities. Meters are used which tell the operator which grade of printing paper to use, and the exposure is then made automatically and the print is conveyed to the developer without further touching by hand; this is done by means of a chute, sloped toward the dish. Usually one worker develops for two printers, and he has to be highly experienced to enable him to keep up with their production speed and produce consistently good work. Fig. 89 shows the arrangement used for two chutes to convey prints into the one bath of developer.

Without automatic printers "visual judging" of each negative is necessary. Extreme skill is required for this, but a very high rate of production can be maintained, and there is nothing so far to beat an experienced worker in this job.

When handling prints in the developer rubber gloves should be worn, or alternatively forceps may be employed. All prints are passed through a rinsing bath before being placed into the fixing solution, which is preferably of the acid-hardening type.

As in film developing, two fixing baths are generally used, prints being transferred from the first to the second. An adequate period is allowed in each to ensure thorough fixation. Definite times are given so that there is no waste of precious minutes between batches. When a box of films has been printed (the films being transferred one at a time to another box) the fixing baths are changed, a new bath being brought into position to receive the next batch of prints. The box of films is sent through to the cutting department. It should be

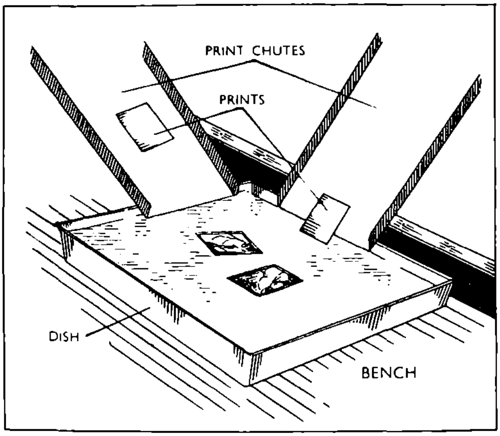


Fig. 89.

mentioned that a wide range of paper contrasts and surfaces is available to D. & P. workers, so that every taste can be satisfied and every type of negative provided with the correct paper.

ENLARGING

The making of enlargements is another service which the photo-finisher must provide, and wallets frequently have to be passed from the printing department to the enlarging room when negatives are received from which both forms of print are required. The two departments are, therefore, generally placed as closely together as possible, often with a "light-trapped hatch" between so that orders can be easily passed to and fro. Enlarging is usually done on bromide papers, which are much faster than gaslight papers. Bromide papers are handled by the light of special yellow safelights.

Most works now use enlargers equipped with an automatic-focussing device which saves time, eliminates focussing by hand and eye, and ensures that every negative is focussed sharply.

Enlarging is a very skilled part of the photo-finishing service, and calls for much experience. In contact printing the negative is printed as it stands, but when enlarging it is frequently necessary to "shade" various portions of the shadow detail to cut down the exposure of such parts while a free and longer exposure is given to the highlights or denser portions so that they will "print through."

In Fig. 90 we see this process being carried out by means of a shader consisting of a silk screen carried on a wire frame. In this case the hand also serves to shade a second area. Further information about the preparation of these shading devices is given on page 305.

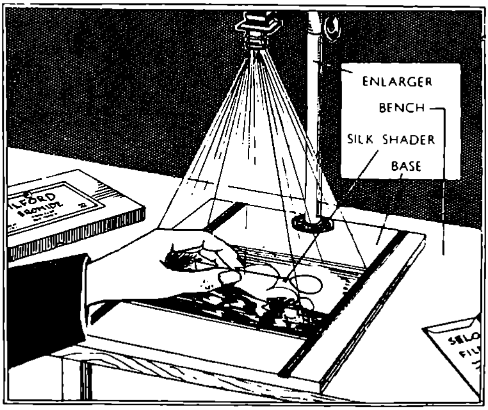


Fig. 90.

Unless customers stipulate a certain paper surface, it is wise to leave the choice to the D. & P. worker, because where a glossy paper may suit one negative it may be totally unsuitable for another which may call for a rough surface paper to minimize the grain.

There is one point in connection with the making of enlargements which should perhaps be made here, and that is that whatever the size of the enlargement the length to width ratio remains constant and equal to the length to width ratio of the negative. In other words it is not possible to enlarge a $4\frac{1}{2} \times 2\frac{3}{4}$ in. negative up to half-plate.

To determine exact dimensions for any degree of enlargement, place the negative on a sheet of white paper and mark out a rectangle to correspond with it (Fig. 91). Then extend the base line "CC" to a length at least as long as the length of the enlargement required. Rule a diagonal line "DD" and then a vertical at the required enlargement length, from the base line until it meets the diagonal

line, such as the dotted line "B." By then ruling a line "EE" and completing the rectangle by drawing the line "ED" we have the exact dimensions of the enlargement without the need for any intricate calculations involving fractions of an inch.

If the length of a $4\frac{1}{2} \times 2\frac{3}{4}$ in. negative be enlarged to fill the length of a half-plate size paper, the width will only fill the portion up to the dotted line at "A." But if the width of the negative is enlarged to

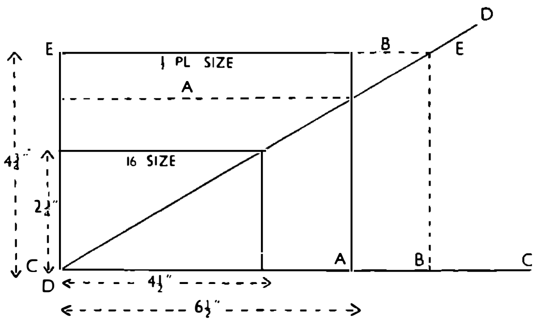


Fig. 91.

fill the width of the paper, then the portion of the negative from the solid line "A" to the vertical dotted line "B" will be cut off.

WASHING AND GLAZING

There are various types of washing machines for removing hypo from prints and enlargements. For very large work the "cascade" type consisting of three or four trays is very suitable (see Fig. 75). The water runs into the top tray, from that into the next (which is a few inches lower), then into the third, and so on. Prints are placed in the lowest tray first and moved up in stages, being allowed a certain time in each tray. This ensures thorough washing and economizes in water consumption. As most large D. & P. works are charged for water by meter, this is an important point.

"Rotary" washers are frequently used for small prints. The prints are placed inside a cage, which is turned at controllable speeds by the pressure of the water on a "water-wheel" at one end. This device makes sure that there is constant agitation of the prints—an aid to quick washing.

Some works have one machine for drying matt and semi-matt prints and another machine for glazing glossy surface prints. There are, however, excellent machines available which will deal with both types of print.

Glazing or drying usually takes a matter of about five minutes. The glazing machines are fitted with stainless steel or chromium drums, both of which need constant care and polishing to keep them in good condition.

All prints are glazed in the batches made at the time of printing, so that when the work is ready for trimming and sorting the batch of wallets is ready to receive the batch of prints, and there are no odd prints left over or mislaid.

FINAL PROCESSES

The neat, even margin around prints is secured by trimming with a hand (or treadle-operated) print trimmer. Usually it is necessary to trim only two edges—sometimes the trimming can be dispensed with altogether, depending upon the kind of printer which is in use and the care with which the printer operator has placed his sheet of paper on the film.

The batches of prints are trimmed in their entirety before sorting is started, so that each batch is sorted complete. A bench may be laid out as shown in Fig. 92. The spaces are marked out and numbered with units figures only, and when sorting these correspond

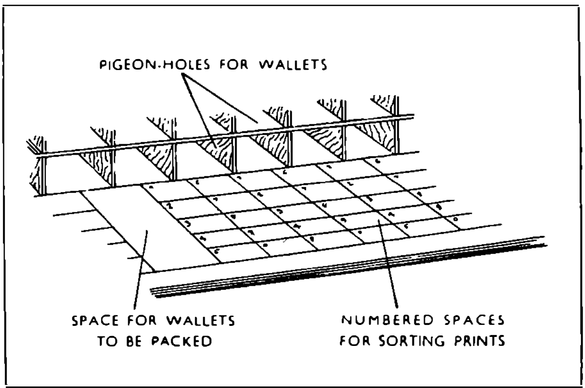


Fig. 92.

with the units figures of the prints. At the left of each "unit" of sorting a space is left for the wallets, which are laid out so that the numbers are visible. After sorting, the wallet is taken up, the prints counted, checked, and examined, and if there are any faulty prints they are sent back for re-printing. Packed wallets are placed in the pigeon-holes at the rear of the bench, according to the dealer for whom they are intended.

Enlargements are trimmed and, as a rule, placed in folders, unless the order has been for mounted prints when they are sent to the

mounting department. Mounting may be done either by the "dry-mounting" method or with specially made photographic mountant. This has the advantage that it will not affect the photographic image, as an ordinary paste may easily do in time. "Dry-mounting" consists of attaching a sheet of shellac tissue between the back of the print and the mount. The print is pressed flat and adheres firmly to the mount when the sandwich is subjected to considerable pressure in a hot press.

FURTHER PROCESSES

A D. & P. works may be asked to undertake a great variety of different kinds of photographic work—copying may be taken as an example. When a dealer requires prints from a print, the finisher has to make a copy negative before he can make the prints. To do this the print is pinned on an easel, illuminated with, say, four lamps, and photographed with a camera kept specially for the work.

Customers who require their prints or enlargements in sepia are usually charged a little extra as this calls for a separate toning process. Prints are first bleached in a solution of bromide and ferricyanide, washed, and the image converted into a rich sepia by immersing in sodium sulphide. Prints have to be correctly exposed and developed to ensure success in sulphide toning. The sulphide toning process is fully described in Chapter XIII.

Colouring of prints is another process which many finishers undertake. This may be done by applying water-colours, transparent dyes, or oil-colours with a small brush. All these colours are simple to apply but a good deal of experience is necessary to obtain good results. Even tints of colour by the first two methods are obtained by removing the surplus colour with fluffless blotting-paper, while in the case of the oil-colour the colour is distributed by a tuft of cotton-wool. Excellent effects can be secured in this way.

Lantern slides are made from amateur negatives in much the same way as ordinary contact prints, and the contrast can be varied by exposure and development. Fixing is carried out in a dish, and washing may be done by placing the slides in a grooved rack made for the purpose.

When dry, the slides are masked either with lengths of gummed tape or by using the masks made for the purpose. White "spots" of paper are fixed to the top of the slides on the emulsion side to indicate which way the slide is to be placed in the lantern to ensure correct projection.

After masking, the plate has to be protected by a "cover-glass," which is merely a sheet of clear glass of the same size as the lantern plate. The gummed tape (which is simply gummed black paper binding) is applied to bind the two glasses together. It is affixed in

the manner shown at the foot of Fig. 93, sticking the binding to the edges of the glass. It is then bent round the two sides and the overlapping ends are snipped off. Further details will be found in Chapter XVIII.

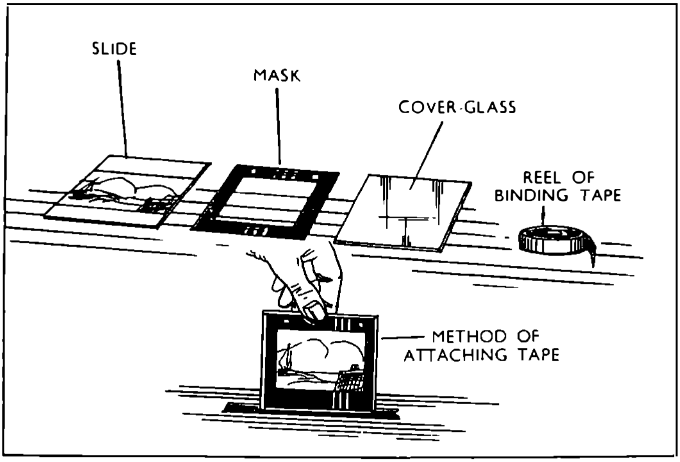


Fig. 93. Binding lantern slides.

PROCESSING MINIATURE FILMS

This chapter would not be complete without a reference to processing miniature films.

When miniature negatives are concerned it is vital that the grain of the developed image shall be as fine as possible and that the processed negative shall be free from marks and scratches. Grainy or scratched negatives will not stand up to enlargement to nine or ten diameters, which is quite common in this class of work.

Great care is, therefore, required in developing the films. Large businesses use 10-gallon vertical tanks. Smaller finishers use tanks for individual films, one type of which is illustrated in Fig. 94. In all cases a normal fine-grain developer should be used, *e.g.*, ID-11, the Ilford M.Q. borax formula. Some firms offer to develop customers' films in one or other of the special "fine-grain" formulæ but in general such treatment to be successful requires that the film shall have had generous exposure.

The fixation of miniature films does not require any special consideration except that prolonged fixation must be avoided. A good hardening-fixing bath should be used to render the film less susceptible to scratch and abrasion marks. As regards washing it is well to remember that frequent changes are infinitely better than prolonged immersion.

After washing, the film is removed from the tank and a clip is affixed to the top and bottom ends to prevent curling. It is vitally necessary to remove all surplus water with a chamois or with a viscose sponge. This operation prevents the formation of "tear-marks" which would happen if small blobs of water were allowed to remain on the film surface.

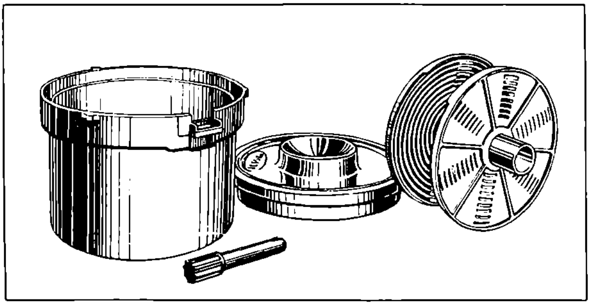


Fig. 94. Miniature Film Tank.

Drying is best carried out at a temperature of about 80° Fahrenheit (27°C.) and the atmosphere must be dust free. Halfway through drying the ends of the film can be reversed to ensure even drying speed and therefore even density.

CHAPTER XVII

TRIMMING, MOUNTING, AND FRAMING

The mounts favoured by photographers to-day are characterized by simplicity and straightforward design. The professional photographer commonly uses mounts of the folder pattern, enclosing a flexible board to which the print is attached by touches of adhesive at the two top corners. This inner mount may be dispensed with and the print made on double-weight sensitive paper and secured in the folder by a line of adhesive down the left-hand side or the print may be mounted on a plain card in a pleasing tint and surface by the dry-mounting method. It would serve little purpose, however, to deal here with the various styles of professional portrait mounts; the makers' catalogues should be consulted.

A similar trend towards simplicity can also be seen in the work of amateur photographers, and this is true whether one considers the mounting of enlargements or the arranging of contact prints in albums which are now available in great variety. Generally speaking, those embodying the loose-leaf principle enjoy the greatest popularity. A type of album which is popular in America has transparent envelopes attached to the album pages by means of cloth hinges. Prints and negatives are placed in the envelopes and the album thereby provides a convenient method of filing negatives and prints. In this connection mention should be made of a recent introduction in which the prints are attached to little hinges cut in a length of tape which is itself attached to the album page. The prints lie closely one upon another, overlapping about four-fifths of their length and by this device the album is made to accommodate a truly amazing number of prints.

Slip-in and Cut-out Mounts. It is hardly necessary to refer to the type of mount and album largely used by amateurs in which the print is slipped between a thin frame or mask of paper and a stiffer card, to which the former is attached round the edges. This slip-in mount is a smaller and cheaper form of the old cut-out mount (now little used except for prints of commercial subjects) consisting of a stout card having an aperture cut with bevelled edges. The print is mounted on a separate card, which is then stuck to the back of the first, so that the print is fixed within the space of the aperture. For photographs of industrial subjects, which often are roughly handled, this type of mount has the advantage of protecting the surface from damage by rubbing. It is also excellent for displaying in uniform size mounts and prints of varying sizes.

There is one style of cut-out mount which can be very attractive in which the cut-out is made from a sheet of thick art paper instead

of card. In this case the print is first attached to a card base and then the cut-out is mounted on top. A variation is to mount the print first on a base of specially chosen tint and to use a cut-out large enough to show a part of this under-tint framing the picture.

Place of Print on Mount. In fixing the size of mount to be used with a given picture and in positioning the print on the mount there are one or two rules which it is well to follow. Individual taste may dictate otherwise in some cases, but speaking generally, observance of these rules will lead to the best effect in the mounted print.

To begin with, the smaller the print the larger the mount may and should be in relation to it. A print as small as 3×2 in. will look well on an 8×5 in. mount whereas one of 7×5 in. on a mount of about the same proportional size of 18×12 in. would look somewhat lost in the space. On the other hand, a pencil line drawn round the larger print will avoid this appearance and make an attractive display.

The print should never be placed exactly midway between the top and bottom edges of the mount, for if so placed it will appear to be too near the bottom of the mount. The space between the top edges of the print and mount should be equal to that between the side edges of the print and mount and distinctly less than that between the respective bottom edges.

An exception to the rule of equal margins at top and sides must be made in the case of the narrow upright print, *e.g.*, one of width about a third of the height. It will be found that if a print of this shape is mounted according to the rule the print will appear to be placed too near the top of the mount. The print should, therefore, be placed so that the side margins are somewhat narrower than the top margin.

With pictures where the horizontal dimension is considerably greater than the upright dimension, the space of mount below should be greater than that above to avoid the "dropped" appearance, but the side margins should be wider than the top margin and in fact a little wider even than the bottom margin.

It must be understood that these rules cannot be applied rigidly in every instance. For example, the effect of a print in which the lines run horizontally may be enhanced by increasing the side margins of the mount. By means of a pair of L-shaped masks the various possibilities may be studied and the best arrangement decided upon. Practice soon makes the decision a simple matter.

Tone and Colour of Mount. Taste and fashion enter so largely into the choice of a light, dark, or coloured mount that it would be rash to generalize. The mount should be of secondary importance and should simply enhance the print without drawing attention to itself. At the present time the preference is for light mounts. A light mount has the effect of adding vigour to the dark tones in a

picture, giving value to the light half-tones, while a very dark mount gives more contrast to the light parts and lightens the shadows. Prints of bright colour, such as the red chalk often used for portrait heads or the green employed for marine subjects, are best mounted

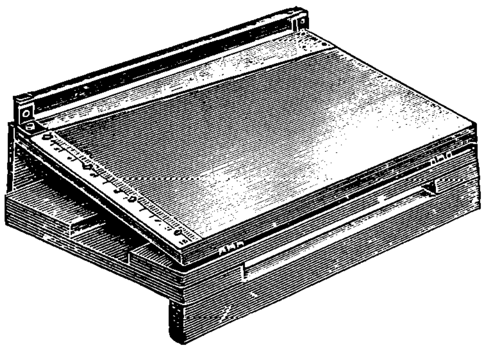


Fig. 95. Merrett trimming desk.

on white or pale cream. In short, it may be said that there are few subjects for which a light mount is not suitable, whereas there are many for which a dark mount is inadvisable.

There is very little scope for highly-coloured mounts, because such mounts nearly always detract from the effect of the picture. The saddened colours are admissible, but here the best effect is obtained by the choice of a colour which harmonizes with that of the print, *e.g.*, brown or sepia mount for brown or warm-black prints, bluish mounts for bluish prints, neutral grey for black prints. Attempts to produce colour contrast between print and mount usually turn out badly and fail to serve the proper purpose of the mount, namely, to display the picture without calling attention to itself.

There is a better chance of success if pronounced colour in the mounting is introduced in the form of a narrow border by means of the border tints described below. A colour which would be intolerable in the mount as a whole may be admissible as a margin one-sixteenth of an inch in width.

Trimming the Print. There are now available many types of apparatus for the rapid trimming of photographic prints and enlargements. One of the best is the "desk" trimmer of the Merrett type (Fig. 95), which is operated by pressing down the top platform.

The necessary register stop, inch rule, and margin feed marks are all incorporated in this trimmer. Small pull-down knife guillotines (Fig. 96) are also obtainable, but it is possible to dispense with machine trimmers by using a straight-edge and a stout celluloid

set-square as a guide. The print is placed on a sheet of glass and trimmed with a sharp knife or, better still, with an old safety-razor blade fixed in a holder. In place of the celluloid set-square, a glass or steel straight-edge or ruler can be used as a knife guide, provided the portion to be trimmed is first marked off on the print. For

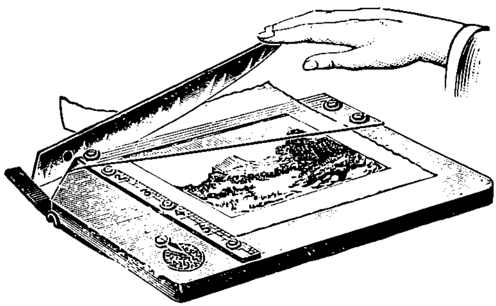


Fig. 96. Merrett Guillotine.

trimming masked prints to show a white border, it is best to use as a knife guide a glass straight-edge through which the edges of the picture can be seen. It will be found quite easy to make a cut strictly parallel to the edge of the front.

Note.—If the picture has not been composed on the enlarging easel it will be necessary to do this before trimming. Take a sheet of celluloid or glass approximately the size of the finished print, but smaller than the picture is before trimming, and swing this about over the print until the desired composition is obtained. Then draw a pencil line round the edge of the sheet and trim.

Deckled Edge. Some pictures, especially those made on rough-surface papers, look attractive if the edges are torn or deckled instead of being cut. This can be efficiently done by placing the print face up between two pieces of cardboard which have been hinged together to form a "book," so that one edge of the print projects about half an inch. This edge is torn *downward* between the finger and thumb, and the other three sides treated similarly, using the edges of the "book" as right-angle guide. There are also obtainable special deckle-edge trimmers which are very speedy in action and most efficient.

Mountants. Many adhesives are used for the mounting of photographs, such as rubber solution, starch, gelatin, Dextrine, and shellac or dry-mounting tissue. The last named is fully described later. Glue, unless free from acid, is not suitable.

Rubber solution. This is a very handy mounting material which permits of prints being detached from the mounts without damage to either.

Starch. This is a cheap material and particularly useful for mounting very large photographs on card or on canvas stretchers. The best way to prepare the starch is as follows:—In a basin put a tablespoonful of starch, *i.e.*, starch powder from the chemist, not the lump starch sold for laundry work. To it add a teaspoonful of water and rub the starch into a smooth paste absolutely free from lumps, and of a fairly firm consistency. If the quantity of water is insufficient more must be added, but a few drops only at a time, and the whole must be carefully rubbed into a stiff but smooth paste. Now pour actually boiling water on the paste (which must be stirred the whole time) until the opaque mixture becomes semi-transparent. Keep stirring the mixture for a few minutes to avoid lumpiness, add a few drops of carbolic acid solution and then allow the whole to cool down. When quite cold remove the skin which will have formed on the top. The starch is then fit for use. It is applied to prints (wet) exactly as directed below for Dextrine mountant.

Gelatin. Mounting with gelatin is a very useful method, as, owing to the rapid evaporation of the solvent, there is little or no after-cockling of the mount. To prepare the mountant take half an ounce (12·5 g.) of cooking gelatin, cover it with water and allow to swell for a few hours. While the gelatin is soaking it is advisable to change the soaking water several times to remove any small quantities of acid or other soluble matter which might interfere with the permanence of the print. Pour off all the water except two or three drams and warm the soaked gelatin by means of a water-bath, until it is dispersed. Then add a little at a time, six ounces (150 c.c.) of alcohol or industrial methylated spirit, stirring steadily with a glass rod and maintaining a moderately high temperature. The solution is then poured off into a wide-mouth bottle or jar and corked or stoppered. Mountant so prepared needs no preservative. When cool, the solution sets, but by placing the bottle in hot water it becomes fluid. A little of this fluid is quickly spread on the back of the print with a soft brush, covering all or only a part as required, and the print quickly placed on the mount. The exact position on the mount should be marked with pencil, because once the print has been laid down it cannot be moved.

Dextrine. Dextrine forms the base of most of the photographic mountants sold by dealers. It is a smooth-working paste with an agreeable odour, and is quite safe to use for photographs.

The making of mountant of the pure white colour and firm consistency of those sold is hardly within the scope of the photographer, but the method is as follows:—Place 64 ounces (1720 c.c.) of water in a clean vessel, standing in a larger vessel in which water is kept

heated so that the temperature of the water in the inner vessel is 160°F. within 1°. Stir in slowly $2\frac{3}{4}$ lb. (1200 g.) of best white dextrine, and when it has completely dissolved add 15 minims (1 c.c.) each of oil of wintergreen and oil of cloves, stirring all the time. A trace of phenol is a satisfactory preservative. Then allow to cool, pour into wide-mouth bottles, cork, and leave in a cool place for a week or two for the mixture to set to a white stiff paste.

It can be applied by rubbing or brushing into the back of the dry print, which is either rubbed into contact with the mount by placing a piece of clean paper on the print or by pressure in a press. Applied in this way there is little cockling.

The mountant can also be applied to the wet prints. Prints taken from the last washing water are placed irregularly face down in a solid block on a clean sheet of glass and the excess of water squeezed out. The mountant is brushed into the back of the top print, the latter peeled off from those underneath, placed in position on the mount and rubbed down with a sheet of clean white paper, or fluffless blotting paper, over it. The surface of the print is then wiped over with a clean sponge. Considerable cockling of thin mounts takes place with wet mounting.

Dextrine mountant is also suitable for mounting photographs by the top edge only, or by the corners of the dry print.

Placing Print on Mount. Particularly when using a wet mountant, a guide mask is of great assistance in placing a print "squarely" in the required position on a relatively large mount. Fig. 97 shows the device and method of use. The mask A (shown in grey tint), cut from a stout flat board, is slightly smaller than the mount with which it is to be used. In it is cut an aperture a little larger than the print, and coinciding approximately with the position the print is to occupy on the mount. The mask is laid on the mount, "square" with it, as can readily be done by placing it so that the borders at top and bottom are equal in width, as also those on the two sides. Two weights are laid on the mask to keep it in place, and the wet pasted print can then be laid exactly in position within the space of the aperture in the mask. The success of this device depends upon the fact that it is easy to judge the correct placing of a print in a confined space, but almost impossible to do so when the bounding lines of the space are several inches away. The exact dimensions of the mask are not of importance, but its outside edges must be strictly parallel with those of the cut-out, and both masks and cut-out must be truly rectangular.

A device of a somewhat similar kind for facilitating the marking of mounts in pencil for central placing of the print in the horizontal direction is a rule, with its zero point midway along its length and with equal graduations extending to left and right from this point. By placing the print on the mount and then laying this scale on it

it becomes a simple matter to find the position in which the print is "central." It will be so when the left-hand and right-hand edges of the print register the same figure on the scale, and when at the same time the right-hand edge of the mount registers the same figure on the scale as the left-hand edge.

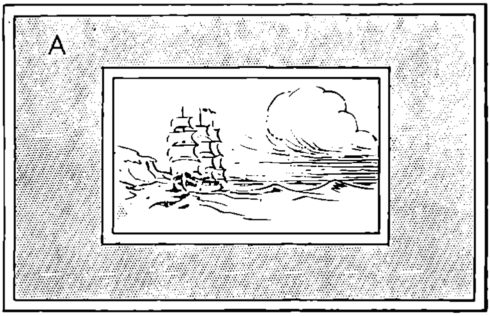
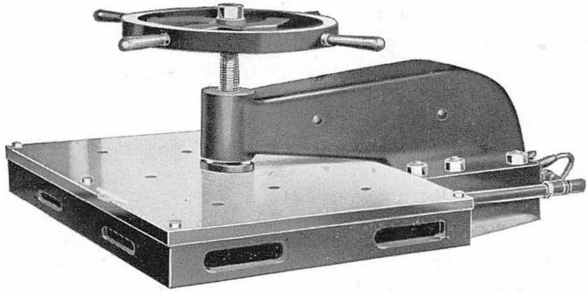


Fig. 97. Mask for centring print on mount.

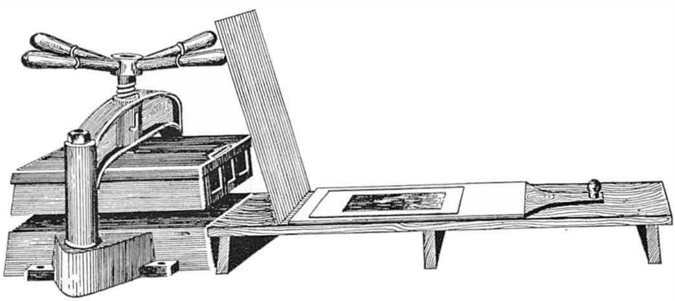
Dry Mounting. The dry-mounting process is now almost universally adopted by professional and trade workers, and to a lesser extent by amateurs. Briefly described, the process consists in interposing between the print and the mount a piece of semi-transparent tissue paper which has been treated with shellac, gum, resin, etc. When heat and pressure are applied the resins in the tissue melt and quickly cement print and mount together.

Prints mounted by this process have a superior finish, the surface of the prints is beautifully flat and free from lumps, and there is no cockling of the mounts. Permanence of the print is assisted by the fact that impurities which may be present in the mount cannot penetrate to the print because of the interposing tissue. A special heated mounting press is necessary for professional work, but an alternative method suitable for amateurs is described on page 342.

The Mounting Press. There are many excellent designs from which to choose, each with different methods of operating. There is the screw-down press, the lever hand-press, the foot-operated press, and the power press. The press illustrated here (Fig. 98) is the screw-down electrically-heated type. The presses are also obtainable for use with gas, and there is one small apparatus in which spirit is used. Having decided which method is most convenient under the circumstances, the next consideration is the size of the machine. It is a mistake to buy a small machine because the average work is of small size. One of the advantages of dry mounting is that a number of prints can be mounted at one pressure. There may also be the



"V" PRESS. Dry-mounting machine.



"J" PRESS.
Fig. 98. Dry-mounting press and bench.
(Adhesive Dry Mounting Co. Ltd.)

occasion to mount enlargements, or to use the heated press to iron or flatten curled prints. A press which gives a 16 × 12 in. heating surface, with accommodation for a mount 24 in. wide, is a useful size. With such a machine a 15 × 11 in. print can be mounted on a 24 × 17 in. mount at one pressure.

Accessories. Two metal cover-plates are usually supplied with the machine, one of matt surface and the other glossy. The matt plate is used for all surfaces other than glossy, although it is possible to mount a glossy print with the matt plate without much loss of gloss. These cover-plates call for careful handling and should be cleaned occasionally with spirit.

A mounting pad, to act also as a carrier for the work, is required to simplify the sliding of mounts in and out of the machine. This cannot be obtained commercially but can be easily made. It is shown in Fig. 99 and consists of a piece of thick cardboard A, at one end of which is fitted a wooden handle. At the other end is

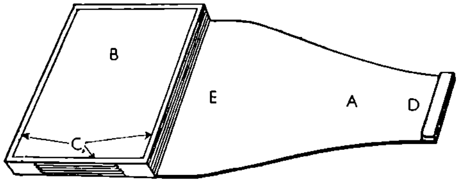


Fig. 99. Pad for dry-mounting press.

built up a pad B consisting of about fifty sheets of thin tissue paper fastened by the edges to the card with strips of thin gummed paper C. On the side marked E the sheets of tissue are left unbound. This pad should not be larger than the metal cover-plate, but about half an inch smaller all round.

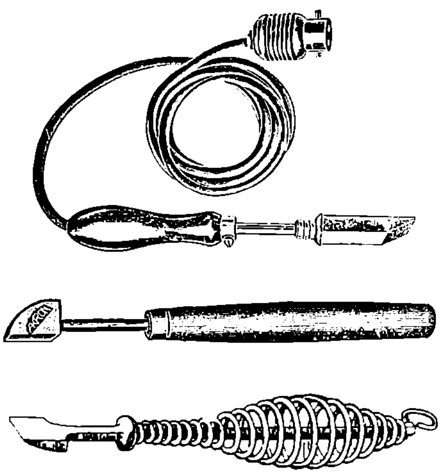


Fig. 100. Fixing-irons—
A, Electric; B, With wooden handle; C, All-metal.

A fixing-iron (Fig. 100) consists of a metal head in a long handle, which when heated is used for "touching down" or partially cementing the tissue to the print and afterwards to the mount. There are several patterns of fixing-irons, *viz.*, the plain type B in a wooden handle, the all-metal type C with a spiral wire handle, the self-heated gas type which has a little burner in the boss, and the electrically-heated iron. The small electrically-heated soldering irons are quite satisfactory. If gas heat is used it is necessary to fit up a wire iron holder over a small gas flame of the Bunsen type. The all-metal irons are the best to use with gas heat. Amateurs may find it convenient to use a small spirit lamp.

Another accessory which will be extremely useful is a sheet of emery paper glued to stout card. The surface is used for cleaning the heads of the fixing-irons, which soon become dirty and covered with burnt particles of shellac, etc.

The Work Bench. The press should be fitted to a table or bench which must be very substantially made. A wooden platform extension is fitted to both sides of the press as shown in Fig. 98. This is to facilitate handling, and to give support when mounting panoram prints or prints on large mounts. The bench or table should be of sufficient height to enable the operator to work the press comfortably.

Flat-iron as a Press. The gas- or electrically-heated domestic flat-iron can be used in place of a press. A sheet of thin, smooth paper is placed over the print to act as a buffer, and the iron pressed fairly heavily on successive portions of the print until the whole is adherent. Specially made flat-irons are available for this work.

The ordinary domestic iron can also be used. It may be heated over gas but it is preferable to place it in a shallow pan of water heated over a gas-ring, the iron being removed when the water boils briskly. It is then used in the same manner as the electric iron. Satisfactory adhesion can be obtained by either of these methods for small prints, but neither of them is so certain in action as a properly constructed hot press.

Dry-mounting Tissue and Tints. Dry-mounting tissue is obtainable commercially in sheets of any size up to 24 × 20 in. There are several makes, the adhesion temperatures of which range from 120° to 150°F. (49° to 65°C.), but all will work quite satisfactorily at 140°F. (60°C.) if the pressure time or "dwell" be suitably varied. Dry-mounting tints are extremely useful for building up surrounds or making mounts with a series of tints. They are thin mounts of matt-surface papers of all "art" colours, coated with a mixture which is similar to that used for tissue and which readily adheres when the mount and print are pressed together in the heated press.

Fixing the Tissue. A piece of tissue, a trifle larger than the print, is placed over the back of the print, the fixing-iron heated and stroked with slight pressure over the centre parts of the tissue. The latter should readily adhere if the heat is correct, but if the iron is too hot the tissue will scorch and lose its adhesive properties. Do not stroke the tissue too near to the edges of the print, as these edges have to be lifted up later to be "touched down" to the mount. This tissuing should be done with the print face down on clean cardboard.

Trimming and Touching Down. The print, with its tissue attached, is trimmed and "touched down" to the mount. Place the print correctly in position on the mount, keeping it firmly in place with

two fingers. Lift one corner of the print, but not the tissue, stroke the tissue with the heated fixing-iron, lift another corner and repeat. The print is then partially but firmly attached to the mount ready for pressing.

Hot-Pressing. All dry-mounting presses are fitted with thermometers, and the bed-plate of the machine should be heated to 140°F. (60°C.). The mount, with its print face up, is placed on the pad, the metal cover-plate placed on top, and the whole slid into the press and squeezed fairly strongly for, say, 3 seconds. If the print adheres to the tissue but not firmly to the mount, then the heat or the "dwell" is insufficient, but if the tissue adheres to the mount but not to the print the heat is too great. Prints made on double-weight paper require about 50 per cent. longer time under pressure, and prints mounted in multiple fashion with dry-mounting tints require still longer. The correct temperature and the time of pressure are soon ascertained by a few trials, and by manipulating the gas tap or the electric switch the heat can be adjusted to a nicety. In mounting a large number of prints by the electrically-heated press, it is usually found that the switches can be left on during the whole period provided no stoppage takes place.

The mounted print, after removal and whilst it is still hot, should be bent outwards for a few seconds. Care must be taken not to get grit or dirt on the cover-plate, as the smallest piece will spoil a print or indent the cover-plate. The prints *must* be absolutely dry before being hot-pressed; if there is any doubt it is a good plan to place the cover-plate on its pad as usual, but without the prints. Then put the plate into the heated press for a second, remove the cover-plate, and place it whilst still hot on top of the prints. Lift after a few seconds to allow any moisture to escape and then proceed as usual.

Mounting Enlargements. There can be no question about the superior finish of a dry-mounted enlargement, but when mounting pictures which are larger than the heated plate, great care is needed to prevent the cover-plate from plate-marking the picture or mount when shifting it about. Large prints may require two or more separate pressures. Satisfactory results can be obtained by observing the following rules:—

1. The cover-plate should be only very slightly larger than the heating plate.
2. The mounting pad should be half an inch smaller than the heating plate.
3. The cover-plate must always be placed centrally over the mounting pad, and in shifting the enlargement, so that each successive pressure overlaps the other, the pad and cover-plate must remain in the centre of the machine.

If the cover-plate makes a line mark on the picture or mount, it is because at that part the cover-plate did not *overlap* the pad.

Framing by Passe-Partout. Passe-partout framing with glass and binding strips affords an easy and inexpensive method of preserving and exhibiting photographs. A 6 × 4 in. print, mounted on a piece of thick art paper of a cream colour and 12 × 10 in. in size, gives a result which is simple and pleasing. Binding strips, ready gummed, can now be obtained at any dealer, and those who require to frame many prints in this style can buy creasing and other devices which will simplify the work. There are also obtainable ready-made passe-partout frames which only require the picture to be fixed under a cut-out.

The manipulation for successful framing in the passe-partout style is as follows:—Mount the picture suitably on thick art paper (not card), and cut a piece of cardboard of the same size for the backing. Clean and cut a piece of glass $\frac{1}{16}$ inch larger all round than the mount. Fasten to the backing card two passe-partout hangers (or thread some strong silk cord through two holes) to provide for hanging. The binding strips must now be chosen; if in doubt as to the most suitable colour, use black.

Cut off strips, each a little longer than the size of glass to be bound and wet them so that they lie flat. Lay one edge of the glass on a strip, press down firmly and then turn up the strip, rubbing it down in contact with the glass with a dry duster. Proceeding in this way, the two long or two short edges are done first and the extra lengths cut off with a pair of scissors when the edges have dried.

When the strips are dry the picture and its backing card are placed together in register, the two laid on the glass with the picture next to the latter, and the projecting gummed strips then wetted and folded over on to the glass to bind all together.

Framing. As in mounting, it has gradually been realized that elaboration of design is best avoided in the frames for photographs, mounted or unmounted. A plain flat wooden moulding of narrow width relatively to the size of the frame is found to set off the photograph to the best advantage. For frames up to 12 × 10 in. size there is a great variety of mouldings of about $\frac{1}{4}$ inch in width in quiet colours and neat inlaid designs. The colour and pattern of the frame must, of course, be chosen to harmonize with the mount. A moulding of more than 1 inch in width is seldom used even in large sizes. Useful guidance is afforded by the general principle that anything elaborate in mounting in the way of borders, etc., is best put in the plainest pattern of frame, whilst a severely plain mount will stand a somewhat more decorative frame.

Framing should be carefully done with a view to providing the photograph with adequate protection from dust and damp. The glass of the frame and the mounted photograph should be bound together with a stout gummed paper strip, the photograph having previously been kept in a warm place to become perfectly dry.

The back-board of the frame (also thoroughly dry) should be a tight fit. After nailing it in place, the entire back of the frame should be covered with stout paper, fixed with strong paste and the whole then left to dry thoroughly.

The following notes have been kindly supplied by Mr. H. W. Thorpe of the Rowley Gallery, Ltd. (Designers and Craftsmen), 87, Campden Street, Kensington, London, W.8.

Form. One of the first considerations in framing is the relationship of the picture to its surroundings. The picture cannot be right if it is out of harmony with the room it is intended to adorn, and, therefore, the aim must be to make the picture complete an otherwise perfect room.

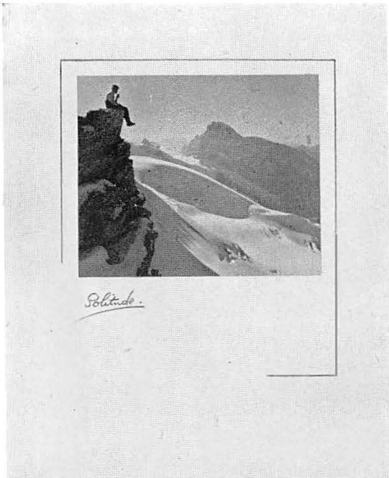
Scale. The frame must be in proportion to the picture. A forceful and strong subject is often best suited by a wide and close frame, but delicate work will tell its story better if a lighter and airier style is adopted.

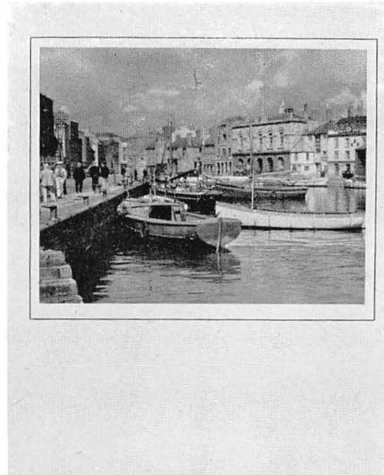
Tone. This is of great importance. Photographs in a high key must have frames to enhance their delicacy and it will be generally found that a light-tone frame will do this perfectly, but a similar frame on a strong work will undoubtedly fail through lack of the support which the stronger work requires.

Colour. Pure colour may be used with advantage. Good greys and blacks in a photograph contrast well with narrow bands of viridian green, vermilion, lemon and orange. Pastel shades combined with silver or silver gilt add charm to high key pictures of ladies and children.

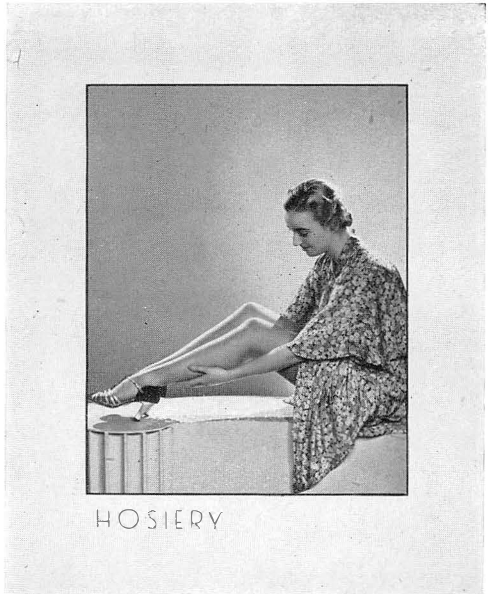
Materials. All kinds of natural woods, either plain, polished, or weathered, are useful, as also are delicate greys when suitably applied. Mouldings with texture like oatmeal, coloured with pearl-like tints, and gold, silver and silver gilt can be used very effectively, as also can cork covered wood and veneers of all kinds. All these materials and many others are available to add the finishing touch to your photographs.

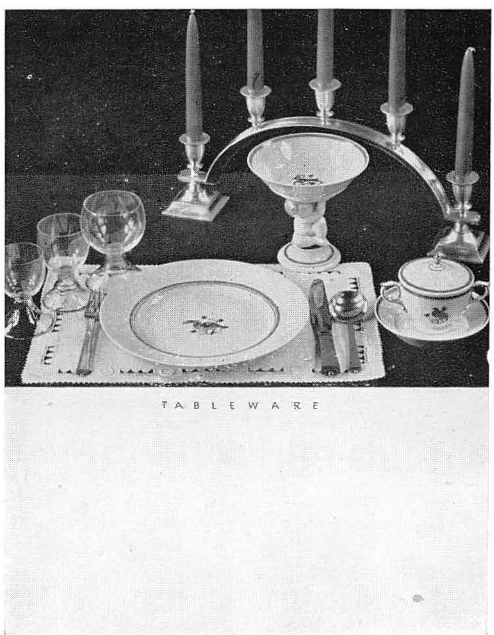
Overlay cut-out mount. Specially suitable for record and technical subjects. Extremely useful where a number of odd size prints are to be exhibited and uniform size mounts are required.





Suggestions for mounting landscape subjects.

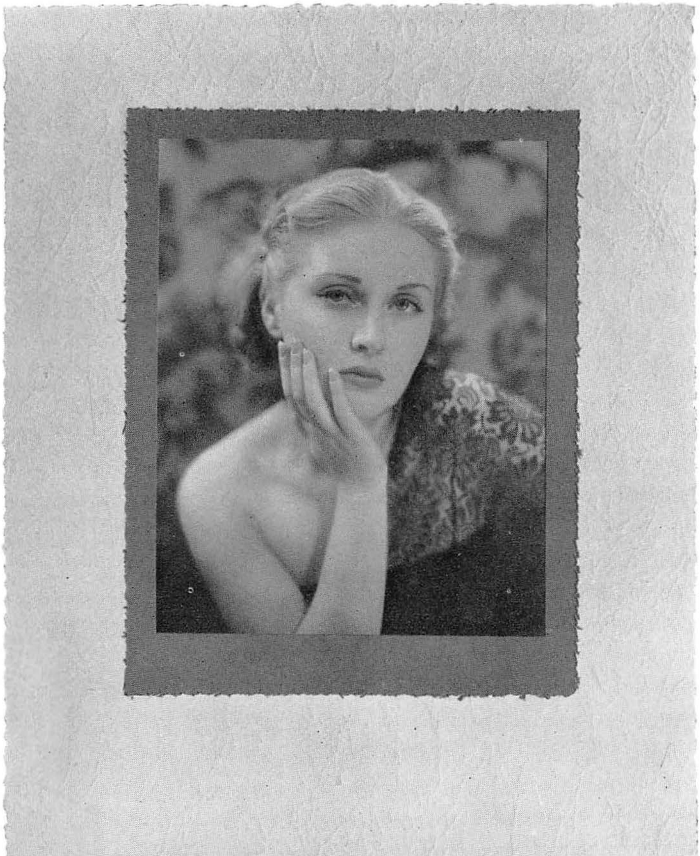




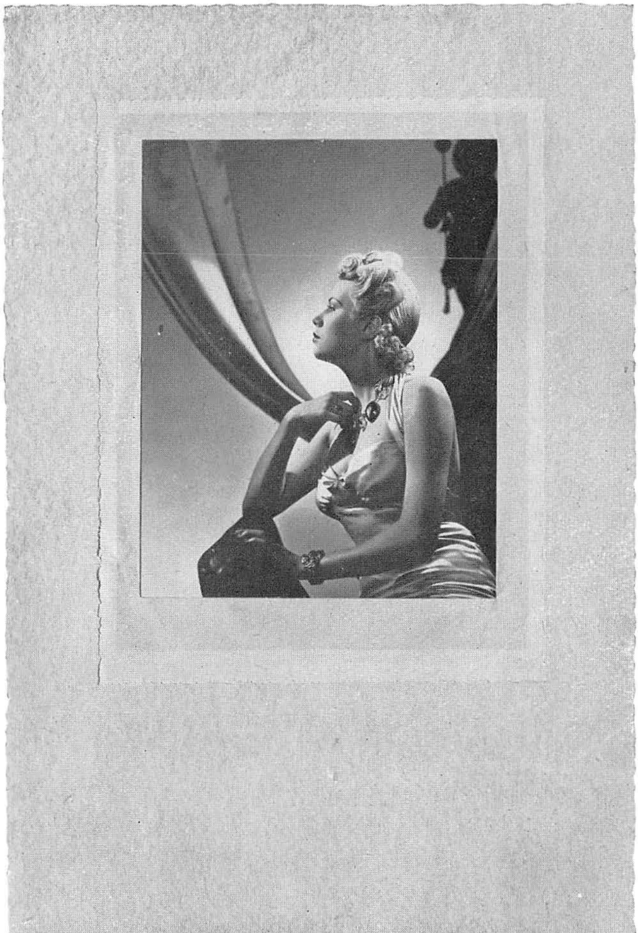
Presenting commercial subjects.

Plate sunk mount.

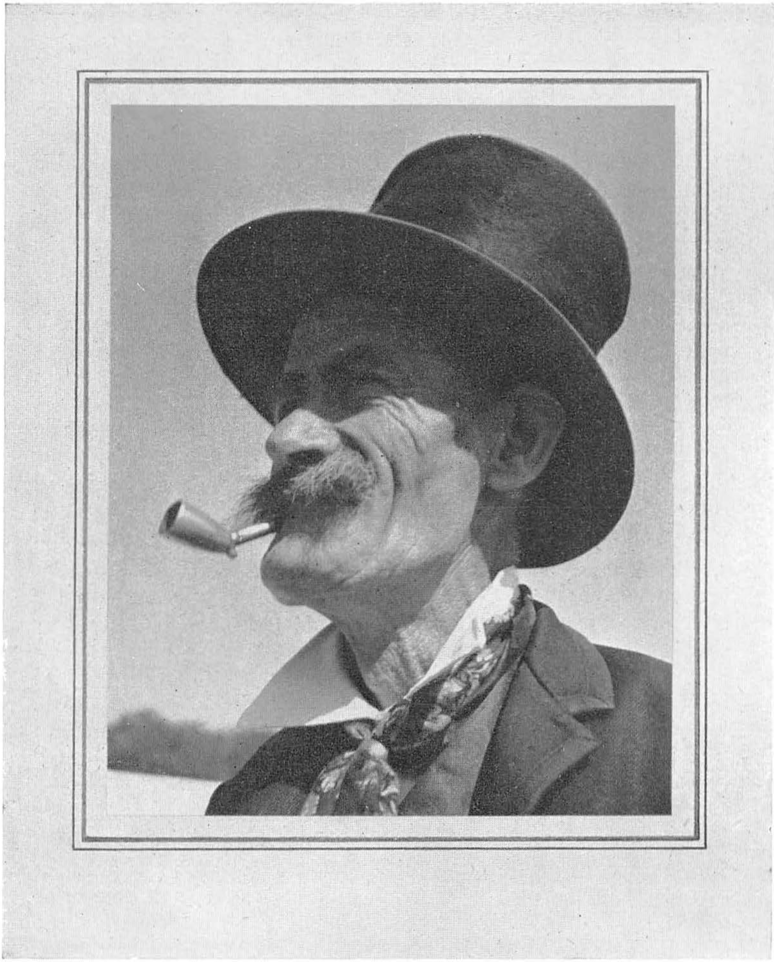
White mount with silver edge deckle.
Very suitable for wedding subjects.



Buff mount with dark border tint.
Suitable for warm tone prints.



Jap tissue border tint overlaid on
dark print surround.



Double pencil rule around light background print.

CHAPTER XVIII

LANTERN SLIDES

●

The Lantern Slide. A lantern slide is a positive transparency prepared for projection in a lantern. It may consist of a positive print made on glass and bound with a cover-glass, or it may be a print upon film bound between two glasses. The standard size for lantern slides in this country is $3\frac{1}{4} \times 3\frac{1}{4}$ in. The actual image on the plate should, however, not be more than about $2\frac{1}{2}$ in. in its longer dimension, to allow for masking and binding. As a picture is almost invariably rectangular, the image on the lantern plate will be about $2\frac{1}{2}$ (or $2\frac{5}{8}$) $\times$ $1\frac{7}{8}$ in. The advent of the miniature film, however, has brought about the popularization of the miniature film slide—film between glass plates—the slide dimensions being 2×2 in.

A good slide, in order to be effective when projected, should be rich in quality with a good scale of tones. In the majority of subjects there should be no absolutely clear glass. Occasionally, in special subjects, there may be a little, but it should be confined to one or two very small points. The shadows should be strong but never opaque; shadow detail should be plainly visible.

Judging a Lantern Slide. Since lantern slides are seen on the screen by transmitted light, their effect cannot easily be judged by simply viewing them when held up to the light. This applies particularly to slides of warm tone. One means for getting a fairly good idea of how the slide will look on the screen as regards depth, brilliance, and colour, is to hold it flat against one end of a cardboard tube about 3 in. diameter and 12 in. length, and to view it from the other end, pointing the tube to the sky or to an opal shade enclosing an electric bulb of about 60 watts.

The Negative. Negatives intended for making lantern slides must be as perfect as possible, technically and mechanically. Movement of objects in the picture, blurring of foliage and such defects as scratches, pinholes, or stains, become aggressively evident when the slide is projected on the lantern screen, many times enlarged.

The back of the negative must be thoroughly cleaned before lantern-slide making is commenced, and care taken that both the face and the back are quite free from dust. Neither the face of the negative nor the lantern plate should ever be touched by the fingers. The habit should be acquired of holding plates by the edges only.

Plates for Lantern-slide Making. Several varieties of Ilford Plates are made specially for lantern-slide work.

Ilford Special Lantern Plates are the most rapid, though they are very slow in comparison with plates made for negative work. They

are intended principally for producing slides of black tone, though with suitable exposure and development or toning warm colours are easily obtained. As they are one of the most rapid lantern plates available, they are specially suitable for producing lantern slides by reduction. Three contrasts are available.

Ilford Warm Black Lantern Plates are about one-twentieth the speed of the Special Lantern Plates. By modifying exposure and development, rich colours ranging from warm black to brown or red-brown are obtained.

The colour of the image with these plates depends upon the developer used and the time of developing; by varying these and by varying the exposure accordingly a series of tones ranging from warm black to red through sepia, brown, and purple may be easily obtained.

Ilford Gaslight Lantern Plates are coated with emulsion very similar to that used for gaslight paper. No darkroom is necessary provided that sufficient care is taken to shield them from direct rays from a lamp. With a normal gaslight developer they give a black tone, but with variation of exposure and development, beautiful warm tones are easily obtained.

The Darkroom. For all varieties of Ilford Lantern Plates, excepting Gaslight, as already stated, a darkroom is essential. Ilford "Special" Lantern Plates may be handled and processed in the light of the Ilford "F" Safelight, No. 904. For Ilford Warm Black Lantern Plates, the Ilford "S" Safelight, No. 902, is satisfactory. The strength of the image must be determined by inspection, and for this purpose the plate may be held quite close to the light for a few seconds.

Backed Plates. For the finest results there is a distinct advantage in using plates having an anti-halation backing. Ilford Lantern Plates may be obtained ready backed, and it is always more satisfactory to use them than to obtain unbacked plates and apply a home-made backing.

Contact Printing. A disadvantage of contact printing in making lantern slides is that no negative longer than $2\frac{1}{2}$ in. can be used if the complete picture is required to appear on the slide. In using larger negatives a portion only can be utilized. Contact printing possesses, however, the great advantage of simplicity and ease of working.

An ordinary printing frame is awkward for the exposure of lantern plates, as the plate is liable to slip after having been placed on the required part of the negative. Fig. 101 shows a frame which is the best of the many patterns devised for the purpose. The ends of an ordinary printing frame are filled in and the open front fitted with a $\frac{1}{4}$-inch board having a central 3×3 in. aperture and covered on the inside with black velvet. An inner frame is hinged to one

side of the frame so that it beds on the negative laid on the velvet. The aperture in it measures a shade over $3\frac{1}{4}$ in. each way. A catch is provided for holding it down. The pressure back, with $2\frac{1}{2}$-inch spring, is hinged to one side of the main frame. In use, the negative is laid face up on the velvet and adjusted in position over the aperture. The inner frame is then turned down to hold it in place. The lantern plate is then laid face down in the aperture of the inner frame and the pressure back put down. By this means a subject which may be askew on the negative is readily obtained straight on the lantern plate. Also a number of identical slides may be printed. When printing from film negatives a sheet of plain glass is laid in the frame. Film negatives smaller than 3 × 3 in. are temporarily attached to a piece of thin celluloid or Cellophane by cutting slits into which the corners of the negatives are inserted. So mounted, they are laid in place on the glass.

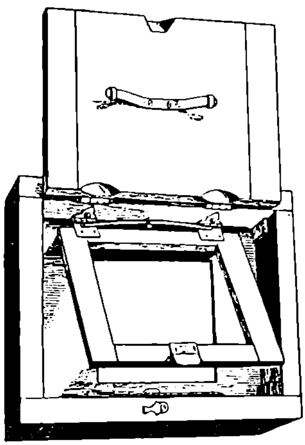


Fig. 101.
Lantern-slide printing frame.

Exposure in Contact Printing. In order to ensure systematic working it is very desirable to make the exposures at the same distance from the source of light for each type of plate, changing the distance only when different plates are used.

For the Special Lantern Plates the approximate exposure with a negative of average density would be at a distance of 48 in. (1·2 metres), with 15-watt half-watt light: without reflector, about 2 seconds, with reflector, 1 second.

For Warm Black Plates the distance may be about 24 in. and with a 15-watt lamp, without reflector, the exposure will be 28 seconds, and with reflector, 14 seconds.

For Gaslight Lantern Plates it is desirable to have the plates nearer to the source of light, or the exposures will be unduly prolonged. For a 60-watt electric lamp the distance should be about 18 in. With a Gaslight Plate 15 seconds will produce a good black tone, or by increasing the time to 40 seconds rich warm tones can be obtained.

It must be recognized that these times must be considered as approximate only. Some negatives, if dense or stained, may require as much as four times the exposures specified; while others may be so thin that less than half these times will suffice.

Lantern Slides by Reduction. Where lantern slides are to be made from negatives which are not the same size as the slides it is necessary to resort to projection-printing or to copying with a camera. In the first case the negative is placed in the enlarger in the usual way and the lantern plate occupies the position usually taken by the bromide paper on the easel. To produce a reduced image it is necessary for the lens to be at a much greater distance from the negative than when used for enlarging, and usually an extension piece will be found necessary. To avoid the necessity for this extension piece a lens of short focal length may be substituted for that normally used in the enlarger. In the second method the negative is photographed while illuminated by transmitted light. It is possible to use daylight as the illuminant, but it is more convenient to arrange for even illumination of the negative by half-watt light.

A simple arrangement is shown in Fig. 102, where an Ilford No. 4 Lamphouse is used, the place of the safelight being taken by a frame

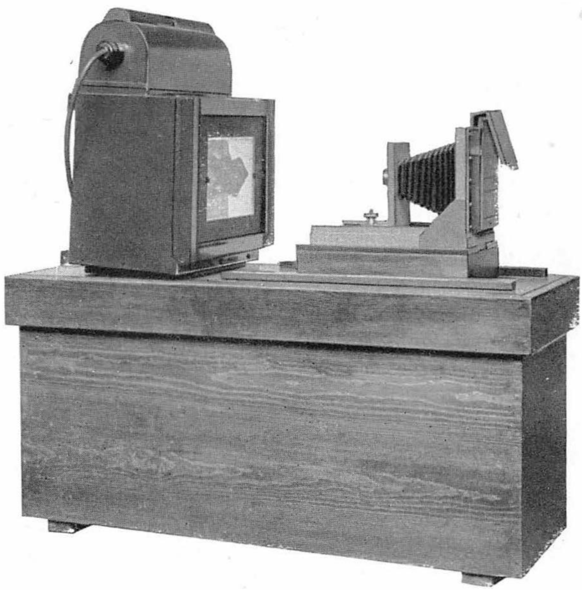


Fig. 102. Making lantern slides by reduction.

holding the negative. This particular arrangement gives very even illumination indeed, but whatever the arrangement the relative distances between lens and negative and lens and lantern plate may be found from the equation given in Chapter I.

$$\text{The degree of reduction} = \frac{\text{linear dimension of original.}}{\text{linear dimension of copy.}}$$

To get negative-lens distance, add 1 to the degree of reduction and multiply the focal length of the lens by the figure obtained. To get the lens-lantern plate distance divide the result by the degree of reduction. For example, if it is desired to reduce from 4 in. to $2\frac{1}{2}$ in. the degree of reduction is 1·6. With a lens of 5-inch focus the lens negative distance would be:—

$$5\ (1{\cdot}6 + 1) = 5 \times 2{\cdot}6 = 13 \text{ ins.}$$

The lens-lantern plate distance would be $\dfrac{13}{1{\cdot}6} = 8\frac{5}{8}$ in.

When making lantern slides by copying with a camera bigger than quarter-plate it is an easy matter to make a carrier for the lantern slide. With a quarter-plate camera, however, an ordinary carrier cannot be used, as the plate is the full width of the plate holder and one inch shorter. The carrier in this case should be of the type

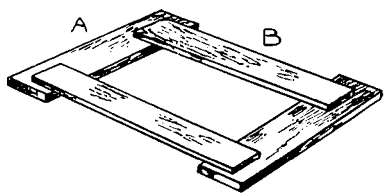


Fig. 103. Carrier for lantern plate.

shown in Fig. 103, *i.e.*, made out of two pieces of stiff card A, a little less than $3\frac{1}{4} \times \frac{1}{2}$ inch, and two strips of thin card B, attached so as to leave a space a little over $3\frac{1}{4}$ in. between the A pieces. This carrier can be made very thin for use in a single metal plate holder.

Focussing. Very critical focussing is necessary. The small image on the lantern plate is magnified many times when projected on the screen, and any defect, due to imperfect focussing or other causes, becomes painfully evident. A focussing magnifier and a special test plate should always be used. The test plate should be an old negative, preferably rather dense, on which some lines have been scratched with the point of a knife; some very bold, some very fine, and others intermediate. This plate can be focussed easily with a degree of precision which cannot be attained with an ordinary negative.

The space between the frame holding the negative and the camera front must be enclosed so as to exclude extraneous light. A piece of card or wood extending from the frame to the front of the camera, with a focussing cloth thrown over it so as to reach down to the board, will be sufficient. Absolute exclusion of light is not necessary, but the only strong light to reach the lens must be that which comes through the negative.

Focussing with Enlarger. As in copying by camera, focussing must be critical, the scratched negative previously described being the best test plate for securing fine definition. A focussing magnifier cannot be used, but a reading glass is an efficient substitute. If a horizontal enlarger is used a simple method of holding the plate on the easel is by means of three stout drawing pins, as shown in Fig. 104. They are inserted in the easel sufficiently far to allow the plate to be placed in position and withdrawn again easily, resting on the two lower pins and sliding into position just under the head of the upper pin. With a vertical enlarger of course the problem does not arise. A cover glass on which a piece of very thin white paper has been pasted is used for focussing and arranging the picture.

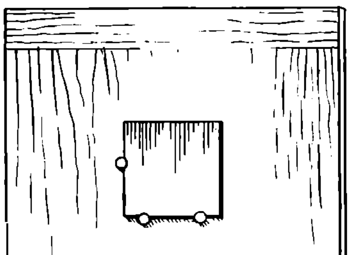


Fig. 104.
Holding lantern plate on easel.

Film Slides. With the coming into fashion of miniature cameras producing up to 36 exposures on strips of 35 mm. film, it has become quite common to run off positive prints also on 35 mm. film and to project the pictures on these strips without separating or mounting them in any way. For this purpose Ilford Diapositive Film, which is on safety base, is used and special contact printing machines are available for making the positive copy. The separate pictures may be detached and bound between glasses 2 × 2 in. (5 × 5 cm.) to be used in the same way as the standard slides, but, of course, in specially designed projectors. Where necessary reduced copies on 35 mm. film can be made in the way already described.

Ilford Special Lantern Plates. For pure black tones the Ilford metol-hydroquinone developer or the Amidol solution given on page 268, for bromide prints may be used. The following formula, however, is specially recommended:—

HYDROQUINONE DEVELOPER ID–16

No. 1. Hydroquinone solution

Hydroquinone	160 gr.	or	9 g.
Sodium sulphite (cryst.)	2 oz.		50 g.
Water, up to	20 oz.		500 c.c.

No. 2. Alkali solution

Sodium hydrate (caustic soda, stick)	90 gr.	or	5 g.
Potassium bromide	35 gr.		2 g.
Water, up to	20 oz.		500 c.c.

For use, take equal parts of Nos. 1 and 2. Slightly warmer tones are obtained by using the developer diluted with water and with the addition of a little more bromide, the exposure being also increased. Still warmer tones may be obtained by using the pyro developer, detailed below, but generally better tones are obtained by using the Warm Black Lantern Plates.

Ilford Warm Black Lantern Plates. The most suitable developers for Ilford Warm Black Lantern Plates are metol hydroquinone for warm black and sepia and pyro for a series of fine warm tones ranging from sepia to red.

METOL-HYDROQUINONE DEVELOPER ID–17

Metol	10 gr.	or	0·6 g.
Sodium sulphite (cryst.)	½ oz.		12·5 g.
Hydroquinone	30 gr.		1·5 g.
Sodium carbonate (cryst.)	½ oz.		12·5 g.
Potassium bromide ..	30 gr.		1·5 g.
Water, up to	20 oz.		500 c.c.

Development should be complete in about 1½ minutes at 65°F. (18°C.). Dilution of the developer gives slightly softer gradation and slightly warmer colour.

A colder tone is obtained by reducing the amount of potassium bromide.

PYRO DEVELOPER ID–37

A

Pyrogallic acid	100 gr.	or	6 g.
Potassium metabisulphite ..	35 gr.		2 g.
Water, up to	20 oz.		500 c.c.

B

Sodium carbonate (cryst.) ..	2 oz.	or	50 g.
Sodium sulphite (cryst.) ..	2 oz.		50 g.
Potassium bromide	20 gr.		1 g.
Water, up to	20 oz.		500 c.c.

C

Ammonium carbonate	1 oz.	or	25 g.
Ammonium bromide ..	1 oz.		25 g.
Water, up to	10 oz.		250 c.c.

The ammonium carbonate must be fresh, and the crystals scraped free from any excess of powdery white deposit.

The table on page 361 gives the times of exposure and development, and the developer adapted to give the particular tone desired. The exposures given are for negatives of average density at a distance of 24 in. (60 cm.) from a 25-watt electric light.

The temperature of the developer should be about 65°F. (18°C.); if it is colder development will take longer; if warmer a shorter time.

Tone	Approximate time of Exposure	Developer	Approximate time of Development
	Seconds		Minutes
Warm Black	14	A, 1 oz. B, 1 oz.	$2\frac{1}{2}$
Sepia ...	21	A, 1 oz. B, 1 oz. C, 60 mins.	3
Brown ...	42	A, 1 oz. B, 1 oz. C, $\frac{1}{4}$ oz.	4
Purple ...	84	A, 1 oz. B, 1 oz. C, $\frac{1}{2}$ oz.	6
Red	168	A, 1 oz. B, 1 oz. C, 1 oz.	18

Other Developers. Although the Ilford formulæ and methods of working described in the preceding pages are specially recommended, various other developers may be used and produce excellent results. Any good metol-hydroquinone developer may be used, including such as are normally used for negatives or bromide paper.

With all such developers, diluting the developer with water and adding from 5 to 10 minims ($\frac{1}{3}$ to 1 c.c.) of a 10 per cent. solution of potassium bromide to each oz. (30 c.c.) of diluted solution will produce fine warm black slides.

A similar result may be obtained by using a normal pyro-soda developer with a similar addition of potassium bromide.

CERTINAL

Ilford Certinal developer may be substituted for metol-hydroquinone or Amidol for Special, Warm Black, or Gaslight Lantern Plates. The working solution is:—

Certinal	$\frac{3}{4}$ oz.	or	20 c.c.
Water, up to	20 oz.		500 c.c.

Warmer tones are produced by adding 12 minims (0·75 c.c.) of 10 per cent. potassium bromide solution per oz. (30 c.c.) of diluted developer and increasing the exposure accordingly.

Ilford Gaslight Lantern Plates. For these plates a darkroom is not necessary. The packet of plates may be opened and all the work carried out in a room lit by gas or electricity, provided that the plates are shielded from the direct rays of the light.

The most satisfactory method of working is to prop a sheet of card or a book on the working table to serve as a shield at a distance of six feet or more from the light, and to carry out the operations of filling the frame and developing the plates behind this shield so that they are screened from the direct light. As soon as the plates are in the fixing bath they may be exposed to the light more freely.

Ilford Gaslight Lantern Plates are principally intended for producing black tones by exposing by contact, and give more contrast than the other varieties.

For contact exposures, using a negative of average strength, at a

distance of 6 in. from the light, the following times will be approximately correct:—

Incandescent gaslight	6 seconds
Duplex paraffin lamp	30 seconds
25-watt electric light	12 seconds

Either metol-hydroquinone or Amidol may be used for development; the results are very similar in quality and contrast. (Formulæ as for gaslight papers, Chapter XIII.)

If the exposure has been correct, development with either solution should take from 30 to 60 seconds at 65°F. (18°C.), according to the negative and the contrast desired in the slide. The tone of the resulting slide will be a cold neutral black.

Warm Tones on Ilford Gaslight Plates. Warm black tones may be obtained on these plates by using the C solution given for Warm

Tone	Approximate time of exposure	Developer	Approximate time of development at 65°F. (18°C.)
	Seconds		Minutes
Black ...	3	Gaslight M.Q.	½
Sepia ...	6	Gaslight M.Q. 1 oz. C. Solution 30 min.	¾
Brown ...	10	Gaslight M.Q. 1 oz. C. Solution 60 min.	2
Purple ...	20	Gaslight M.Q. 1 oz. C. Solution ¼ oz.	3
Red	48	Gaslight M.Q. 1 oz. C. Solution ½ oz.	4

Black Lantern Plates in conjunction with the gaslight metol-hydroquinone formula, and increasing the exposure and the proportion of the C solution as tabulated above. A range of most attractive tones may be obtained by taking advantage of these variations.

The pyro-soda developer, restrained only with bromide, given as an alternative method, will also produce very fine warm tones ranging to a rich red-brown on Gaslight Lantern Plates.

The Selo M.Q. developer, sold in packets, may be used for pure black tones. The contents of one packet should be dissolved in 4 oz. (100 c.c.) of warm water.

Fixing. After development all lantern slides should be rinsed in water for a few seconds and then placed in the fixing bath. This latter may be the solution of hypo with addition of potassium metabisulphite given elsewhere for negatives. It is better, however, to employ a fixing-hardening bath, made up with chrome alum and metabisulphite as directed on page 456. While the slide is in the fixing solution, the dish should be rocked occasionally to ensure

even action. On no account should the fixing bath be overworked. Fresh solution should be used for each batch of slides.

Washing and Drying. After fixing, the slides must be washed thoroughly either in running water or in water frequently changed for about an hour.

If the slides have not been hardened by using the fixing and hardening bath, it is advisable to immerse them for ten minutes after washing in:—

Chrome alum	20 gr.	or	1 g.
Water, to make	20 oz.		500 c.c.

They must then be again washed for about 15 minutes.

When the plate is taken from the final washing water it should be held under the tap, or, if that is not practicable, placed in a dish of water, and the entire surface rubbed very gently with a plug of soft cotton wool which must be perfectly free from grit. This removes any deposit which may have settled on the film from the washing water, and leaves the surface of the slide bright and clean. The slides should then be set on edge to dry where no dust can settle on them.

Toning Lantern Slides. Slides made on Ilford Lantern Plates may be toned by any of the methods given for toning bromide prints. By far the best of these processes is that of sulphide toning by the two-bath method as given on page 275 for bromide paper. The only point to be mentioned is that it is best to dry the slide after fixing and washing before toning by the sulphide method.

Methods of toning with uranium or copper are not satisfactory. Because of the opaque nature of the toned image, slides toned by these methods lack the much desired transparency in the shadows. Moreover, it is very difficult to tell, when toning, the colour which the slide will exhibit when shown on the screen. There is, however, one very simple but little known method which can be recommended. The slide is simply bleached in a strong solution of mercury bichloride, washed, and dried. Although appearing nearly milk white, the picture on the screen is of rich warm brown colour with great transparency in the shadows. This process softens the contrast to some extent and is most suitable for slides from vigorous negatives.

Intensification. As a rule it is not worth while to intensify a slide which is deficient in vigour or depth—another exposure should be made. If, however, an intensifier is required, the best for the purpose is the chromium formula made up and used exactly as given on page 458 for negatives. It has been stated that slides should never be intensified by a process in which the final image contains any metallic mercury, and that slides so treated are liable to change in colour, etc., by exposure to heat in the lantern. The following formula has, however, been found to give very satisfactory results of a very beautiful colour:—

A

Mercuric chloride ..	1 oz.			25 g.
Potassium bromide ..	1 oz.	}	or {	25 g.
Water, up to	40 oz.			1000 c.c.

B

Sodium sulphite (cryst.) ..	2 oz.	}	or {	50 g.
Water, up to	20 oz.			500 c.c.

Wash the slide thoroughly after fixation and immerse while wet in solution A until bleached. Wash for 15 minutes and blacken in B, after which give 15 minutes wash. The effects of this intensifier can be removed by placing the slide in the ordinary fixing bath. It is important that lantern slides intensified in this way should be varnished, see page 365, otherwise they may deteriorate after about five years.

Reduction. A slide that is too strong, especially if the lighter tones are veiled, may frequently be improved by use of the ferricyanide reducer. Reduction, unlike intensification, does not detract from the transparent character of the image. With a negative that is deficient in contrast a good slide may be obtained by developing fully and then reducing in a weak ferricyanide solution, or preferably in the iodine-cyanide reducer. When in doubt in developing a lantern slide it is preferable to prolong development and subsequently reduce the slide if necessary, rather than obtain a thin slide which requires intensifying, since reduction acts to a greater degree on the light tones than on the dark parts of the image.

Lantern Slides of Line Drawings, etc. Lantern slides can be made of line drawings, pages of manuscript, etc., to show strong black lines on a perfectly clear ground by using Ilford Gaslight Lantern Plates or Ilford Process Plates. The negatives for making these slides should be on Ilford Process Plates (backed), so as to yield clear lines on a ground of sufficient density to produce clear gelatin free from deposit on the lantern plate.

Printing Clouds in Lantern Slides. In making lantern slides of landscape subjects in which no clouds exist in the negative, it is a simple matter to add clouds. A suitable cloud negative is used to make a second slide, this being used as a cover glass for the landscape. As the two plates must be bound together film to film, it is evident that in making the sky slide the cloud negative must be reversed in the carrier or printing frame. The cloud negative is roughly shielded to the contour of the landscape, and when developed and fixed, after a brief washing, it is held in the hand with its back to the back of the landscape slide, and the reducing solution previously described applied with a water-colour brush so as to remove those parts of the clouds which overlap the landscape. Frequent immersions in plain water are necessary in order to prevent any harsh line showing where the reducing solution has acted.

Varnish for Lantern Slide Transparencies

Gum dammar	140 gr.	or	8 g.
Benzol	4 oz.		100 c.c.

Method of application to avoid extraneous grits, etc. Place a clean glass funnel on stand with filter paper folded for use. Hold the slide in the left hand by a corner and pour a small quantity of the varnish into the filter catching the filtered varnish, quite close to the stem of the funnel, on the middle of the slide. Allow sufficient varnish to flood the surface of the slide and then quickly pour it back into the funnel, holding the slide edgeways vertically and rocking to avoid streaks. The varnish dries extremely rapidly, and any which has run on the back of the slide can be removed with benzol after binding.

This varnish is of use in preparing handwritten slides with diagrams, etc., for lecture purposes, if a clean lantern slide cover glass is prepared by coating with the varnish in the manner described for varnishing lantern slides. Indian ink should be used for the writing and there is no necessity for binding.

Taking out Defects. Pin-holes and similar small defects require "spotting out," as this operation is called. A fine water-colour brush with a good point is necessary, and transparent colours, such as Johnson's "Photo-tints" for colouring photographs. Ordinary water colours should not be used if the others are obtainable, as, being pigments, they appear as opaque spots when projected by the lantern. The slide is placed on a retouching desk and a little of the colour applied with the brush. Too little rather than too much should be applied; more can always be added if necessary.

When the slides are thoroughly dry there only remains masking and binding them with a protective cover-glass to make them ready for the lantern.

Masking. A mask of thin opaque paper is attached to the film of the lantern plate by a touch of gum at each corner. This mask covers the margins of the plate, leaving only the picture exposed. Masks can be bought cut to various sizes, but the objection to the commercial masks is that the opening is frequently neither the requisite size nor the desired shape. Many lantern-slide makers prefer to build up the masks for their slides with four strips of paper. A series of strips of thin opaque paper, black or any suitable colour, can be easily cut with a sharp knife and a straight-edge. They should be just under $3\frac{1}{4}$ in. long and in widths ranging from half an inch to an inch. From these strips four can be selected to suit each individual picture and mask it to the best advantage. Each strip is attached to the film by a little gum at each end.

When the masking is complete, two white paper discs are attached to the two top corners of the mask. These are for indicating to the lanternist the position that the slide should occupy in the lantern,

which is the face and which is the top. These two spots will be on the face of the slide when finished.

Binding. The only operation now remaining is binding the slide to a cover-glass. The object of this cover-glass is the protection of the film of the slide from injury by accident or even ordinary handling.

Cover-glasses are readily obtainable. They are pieces of thin glass of good quality the same size as lantern plates. The slide is carefully dusted and a cover-glass, after cleaning, is attached by means of binding strips. Commercial slide makers always bind the cover-glass to the slide by means of one long strip, 14 in. long and about $\frac{3}{8}$-inch wide. This is gummed and attached to one edge of the slide. Then, by mitreing the corner, it is taken to the next and in succession to the other two edges, and finally is brought back to the starting point by overlapping the part originally bound.

This is an operation which requires considerable practice and dexterity to carry out successfully, and most amateur workers prefer to bind their slides with four separate strips. This is equally satisfactory and a very easy task. Binding strips for this method are sold ready gummed, or anyone can easily cut the necessary strips and apply the gum when using them. They are cut in the same manner as the masking strips, just under $3\frac{1}{4}$ in. long and from $\frac{3}{8}$-inch to $\frac{1}{2}$-inch wide. The paper should be thin and flexible; if white, titles, notes, or numbers can be written on one of the binding strips.

One important point should be observed in binding lantern slides, and that is to have the slide, cover-glass, and mask absolutely dry. All three should be dried by keeping them in a warm place for half-an-hour or so and bound whilst still warm. The reason for this is that slides which are treated with observance of this precaution are much less liable to show the unsightly "dewing" on the screen when placed cold in the warmth of the projection lantern. Professional slide makers usually varnish their slides, and this is a further preventive of the same effect.

CHAPTER XIX

OIL AND BROMOIL PROCESSES

Prints in Greasy Ink. Prints made by these processes exhibit a distinctive quality, due to the use of an image-forming pigment in a greasy medium, and for the same reason have a high degree of permanence. Moreover, the processes afford immense scope for hand control in the production of the pigment image.

Materials and Appliances. Apart from the usual equipment for making prints, the requisites for the oil processes comprise inks, brushes, and some other accessories sold by photographic dealers. The inks (of many colours) consist of pigments prepared in oil and somewhat resemble those used by painter artists in oils. Brushes of various kinds and sizes are used for applying the ink to the print. A brush of special dome shape, known as stagsfoot (Fr. *pied de biche*) is largely used.

The Oil Process. Gelatin-coated paper, *e.g.*, the double transfer paper sold for the carbon process, is sensitized with bichromate. The "spirit sensitizer," also sold for the carbon process, is the most convenient for this purpose, or a solution may be made by adding 2 parts of pure alcohol (rectified spirits of wine) to 1 part of 6 per cent. solution of ammonium bichromate.

On a perfectly flat board lay first a sheet of blotting paper larger than the paper to be sensitized, and on this the paper, pinning at the corners to make secure. Roll a piece of cotton wool in the form of a ball about the size of a walnut, and around it wrap a piece of fluffless flannel material to form a pad. Dip this pad in the spirit sensitizer, well charging it, and, starting at the top left-hand corner of the sheet, stroke the paper right across to the right corner, leaving an even tint of bichromate. Repeat this action lower, and proceed in this way until the whole of the sheet has been stained.

Now, without loss of time, recharge the pad and repeat the process, but with strokes at right-angles to the first. Place the sheet in a warm, dark cupboard to dry. In the course of fifteen minutes it will be ready for use.

The negative for oil printing should be of good contrast. The sensitized paper is printed from it in an ordinary printing frame by good diffused daylight. By degrees a brown image is formed, and when detail is plainly seen in the highlights the print is removed and washed in running water until the stain has entirely disappeared.

It is then hung up to dry. It is now insensitive, and all subsequent work may be done in daylight or artificial light.

When thoroughly dry, soak the print in water at about 65°F. (18°C.) for about an hour or more if there has been over-exposure. It is well to use a printer's actinometer and, when the most suitable exposure has been determined, to mark the negative so that the exposure may be repeated at any future time.

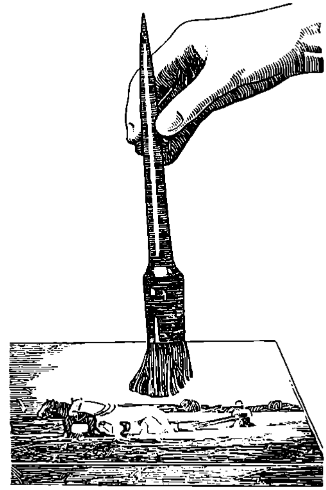


Fig. 105.
Inking—Beginning of stroke.

Inking Oil Prints. On a sheet of plate glass lay two sheets of damp blotting paper, and on these place the soaked print. Mop it surface-dry with butter muslin rolled up in the form of a pad. Cut four strips of waxed tissue paper, about an inch wide, dip them in water and then lay each along one edge of the print, covering the latter to the extent of half-an-inch. This gives the print a safe edge or margin. Go over the waxed tissue strips with the butter muslin, pressing well to remove all surplus water.

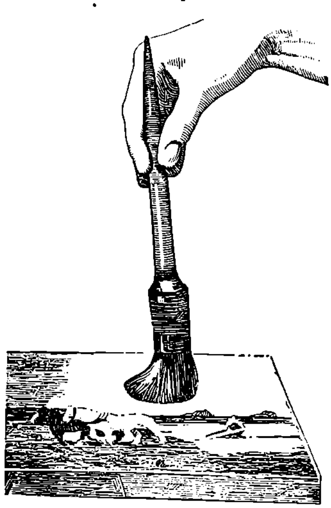


Fig. 106.
Inking – End of stroke.

The print is now ready for inking. On a piece of white opal or glass, place a little ink, about the size of a pea, and rub it out thin and smooth with a palette knife. Take up a stagsfoot brush, holding it by the extreme end of the stem so that it hangs loosely and perpendicularly. Note that the hairs of the brush are in the form of an animal's hoof with a toe and heel. All strokes must be so made that the toe touches the paper before the heel (Fig. 105). Now pat the ink until it is worked out very thin and even. Next choose some portion of the print where detail is seen in the swollen gelatin and pat the surface with the brush, striking the paper with

the toe and gently pressing until the heel touches and the hairs are well spread (Fig. 106). For the second stroke raise the brush until only the toe hairs are touching the paper, then repeat as before. Begin slowly, and speed will come automatically with practice. Work over the whole print in this way and, recharging the brush with ink at intervals, build up detail until sufficient density has been obtained.

Inks for Oil Printing. In the preparation of the image for inking, the various parts of the gelatin film are tanned in proportion to the density of the image; the amount of water retained by the gelatin is, roughly, inversely proportional to the amount of tanning, and the drier the film the more easily is the ink retained. Thus the action of the brush is to load the shadows with ink and clean up the highlights, forming the oil picture.

The quality of the ink must, however, be suited to the amount of water in the print. Inks are supplied in hard and soft grades. The work should be commenced with the hard grade. If the print is not over-soaked the hard ink will take. If it refuses, a little soft ink must be worked into the hard ink. When the ink is reduced to the right degree of softness the image will immediately appear under the strokes of the brush, but any over-softening will ruin the work, so that great care must be exercised in the softening.

Should the finished print have a dirty or flat appearance it may be dipped in cold water, returned to the glass and re-mopped. If a clean brush be now worked over it the muddiness will disappear, leaving the print bright and clean.

Stagsfoot brushes are supplied in hog's bristles and soft fitch hair. The work of inking should begin with the hog brush; the finishing is better done with the fitch brush.

When dry, the print may be touched up with a pointed piece of rubber and a sable brush with ink.

The Bromoil Process. A Bromoil Print consists of a pigment image on the surface of a bleached special bromoil paper, and this is obtained in the following order. The paper is exposed, developed, fixed, and washed as for ordinary bromide work, bleached in the special bleacher, rinsed, fixed, washed, and dried. The bleached print after soaking for a short time in water is laid flat, all surface water mopped off, and then worked upon with a specially shaped brush carrying small quantities of ink similar to printers' ink, when the image will be gradually built up.

Bromoil Transfer is a further elaboration of the above, in which the oil pigment image is transferred under pressure from the gelatin coated original to any selected paper.

The Developed Print. The developed print required is one which appears decidedly over-exposed and flat, with full detail in high-lights, and an appreciable deposit of silver everywhere, excepting on

the borders which should be masked for about half-an-inch all round. The best type of negative is one which would give a satisfactory contrast on a normal grade of bromide paper.

Any ordinary metol-hydroquinone or Amidol developer may be used (avoiding developers which contain caustic). Development should be complete in 2 minutes at about 65°F. (18°C.) in developer of normal strength as for bromide prints, unless softer prints from contrasty negatives are required, when developers may be diluted with one or more parts of water. The following developers are recommended:—

METOL-HYDROQUINONE (ID–20)

Metol	15 gr.	or	0·75 g.
Sodium sulphite (cryst.)	1 oz.		25 g.
Hydroquinone	60 gr.		3 g.
Sodium carbonate (cryst.) ..	$1\frac{1}{2}$ oz.		40 g.
Potassium bromide	20 gr.		1 g.
Water, up to	20 oz.		500 c.c.

Dissolve in the order given in warm water and use at 65°F. (18°C.). For normal work dilute 1 part with 1 part water, or for softer results, with 2 or 3 parts of water.

This developer keeps indefinitely in well-stoppered bottles.

AMIDOL (ID–22)

Sodium sulphite (cryst.)	1 oz.	or	25 g.
Amidol	60 gr.		3 g.
Potassium bromide (10 per cent. solution)	80 min.		4 c.c.
Water, up to	20 oz.		500 c.c.

This developer keeps in good condition for one day only. It should be used at full strength and only diluted further if softer prints are required.

After development, prints are rinsed in clean water and fixed for 10 minutes in a plain (not acid) hypo bath:—

Hypo	4 oz.	or	100 g.
Water, up to	20 oz.		500 c.c.

followed by washing for at least half an hour in running water, or 6 or 8 changes of 5 minutes each.

Bleaching. Prints may be dried before bleaching, if desired, but good results are made more certain by carrying out the bleaching as soon as the above washing is completed. If the prints have been dried they should be well soaked in water before bleaching.

The wet prints are placed in the diluted bleaching solution and should be kept evenly covered and submerged with gentle rocking until all signs of black have disappeared, leaving only a pale lemon colour image. Bleaching should take 3 to 4 minutes. Immediately

the black image has disappeared, prints are transferred to running water and washed for 2 minutes and are then refixed for 5 minutes, in a fresh portion of the hypo solution mentioned above, not acid-hypo. This should fix out the lemon colour of the image and leave only a faint pale grey. Then wash for half an hour and dry the prints, preferably by hanging from a line after wiping all loose water from both the back and front to ensure the even drying which is essential.

BLEACHER (Stock solution)

Copper sulphate	2 oz.	or	50 g.
Potassium bromide	2 oz.		50 g.
Potassium bichromate	50 gr.		2·5 g.
Sulphuric acid (concentrated) ..	40 min.		2 c.c.
Water, to	25 oz.		600 c.c.

Add the acid to the water first.
For use, take one part of stock solution and add four parts of water.

Pigmenting. Although the prints may be pigmented straight away following washing, it is preferable that they should be dried, not only that they may be stored for pigmenting at any future time, but mainly because good results are then more certain.

Soak the dried, bleached print in clean water until a distinct relief is visible in the highlight portions; this may require anything from 5 to 30 minutes according to the temperature and softness of the water supply. Even soaking, avoiding air-bells, is most important.

In the meantime, place a very small portion of hard ink on a palette or piece of glass and spread it out thinly with a palette knife.

When the print has received the requisite soaking, transfer it face up to a sheet of damp blotting paper laid on a sheet of glass and mop all water from the surface with a piece of old linen or other fluffless material.

Proceed to pigment the print. With a fairly large fitch hair stags-foot brush held perfectly upright, very lightly dab repeatedly first the ink and then a clean place on the palette to form a thin, even patch of ink away from the main supply. The brush should now be carrying a light supply of ink on the tips of the hairs only, and may be applied to the print.

Still holding the brush perfectly upright, quickly cover the whole area of the print, frequently replenishing the brush from the thin patch of ink and when required from the main supply patch, but always visiting the thin patch on the palette with the brush before it goes to the print. The brush action required is a combination of light dabbing with a slight drag. With the toe of the brush away from you, and commencing at the top of the print use a quick up and down motion which presses the tips of the hairs to the print, toe first and pressing until the heel touches, then lift slightly, move forward, and repeat downward pressure, dragging the hairs slightly

along the surface with each forward movement. The image will build up as the brush work proceeds if the brush is frequently replenished with small supplies of ink, until sufficient strength has been obtained. Quick working is desirable so that the surface does not dry before completion of the pigmenting.

If the gradation is hard and lacking detail in highlights a softer ink, or ink very slightly thinned with medium, may be applied. If too soft, place the print in water for one minute, return to the blotting paper, carefully remove every trace of water from the surface with fluffless material, and very lightly dab with the brush all over the surface. Hopping or lightly bouncing the brush on the surface, will be found to emphasize highlights.

Finally, white margins of prints may be cleaned by wiping with wet linen stretched over the finger, and the print pinned up to dry, remembering that the ink image remains soft and easily damaged for seven to fourteen days.

When surface dry, dark hairs and bits adhering may be removed by the judicious use of a knife and highlights improved, also white spots and blemishes can be spotted out with thin ink and a fine brush.

Brushes, knife, and palette should be cleaned before being put away by wiping with a few drops of petrol on a rag.

A Few Pointers to Success. The making of the original print largely determines the success or failure of the Bromoil; it should be well exposed and carefully developed, and should appear dark and flat compared with an ordinary bromide print.

When for any reason, such as in warm climates, the temperature of working solutions or washing water is much above 65°F. (18°C.), to prevent excessive swelling of the gelatin the print may be rinsed in a weak alum bath after development and before fixing, the print being well rinsed in water before going into the hypo.

Do not use an acid-hypo bath at either stage.

To ensure a colourless bleached image, the fixing following bleaching should be in clean solution and not that which has been used for fixing the developed prints.

Even drying following bleaching is very important. Mysterious spots and markings are liable to result from tears or dribbles of water being left to dry unevenly on the print.

In pigmenting, do not overload the brush with ink and avoid using soft ink in the early stages.

Avoid water either on the brush or on the print.

A print which has been inked unsatisfactorily may be cleaned off with a little petrol on a rag, under a running water tap, dried, resoaked, and inked up again.

CHAPTER XX

PHOTO-MECHANICAL PROCESSES

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Photography and the Printing Press. The employment of photographic methods of copying and of preparing the plates from which impressions are taken in a printing machine, has long formed the basis of commercial illustration work, pictures in newspapers, illustrated supplements, catalogues, and the numerous kinds of reproductions sold by art dealers. It is beyond the scope of this Manual to deal fully with the principles and technical details of these numerous methods. This is done in the *Ilford Manual of Process Work*, by L. P. Clerc, but a general account is given in this chapter of the methods in current use, in the "process" or "photo-mechanical" trades, which constitute an important industry.

Types of Processes. There are three chief types of photo-mechanical processes; relief or typographic, intaglio, and surface or planographic. In the first, represented by the line and half-tone blocks used for newspapers and many other kinds of printed matter, the parts of the metal block or plate which receive the ink and convey it to the paper are raised above the other parts. In the intaglio process, *e.g.*, photogravure, the parts containing the ink are sunken or recessed, and the ink, which is altogether different from that for typographic printing, is sucked out on to the paper when the latter is pressed against the inked plate or cylinder. In surface methods, *e.g.*, photo-lithography and collotype, the original is reproduced on a flat stone or metal plate, or gelatin surface, by a process of bichromate printing by which greasy ink, when applied by a roller, is held in proportion to the tones of the original. In a variation of the surface process known as offset, the ink impression on the plate is transferred to a rubber-covered roller, from which in turn it is conveyed to the paper, which may be much rougher than when printing is done from a rigid plate.

Originals for Reproduction. Most originals having a flat surface can be photographed directly with a process camera. Following are a few such subjects arranged in decreasing order of ease or suitability for direct reproduction for relief, surface, or intaglio printing.

1. Line drawings and good type impressions.
2. Monochrome drawings in flatted oil or body colour.
3. Glossy bromide prints.
4. Purple-toned P.O.P. prints.
5. Matt-surface bromide prints.
6. Toned bromide prints and carbon prints.
7. Engravings and etchings.
8. Water-colour paintings (in colour).
9. Paintings in oil or body-colour (in colour).

Many other subjects, however, are unsuitable for direct reproduction. These include objects such as glass and silverware, or carpets and large paintings, which cannot be photographed with a process camera owing to their size. In all such cases a negative is made, from which a bromide print or transparency is taken, to be used as an original for photo-engraving. This, of course, is a branch of pure photography, but it is work that is frequently undertaken in the process studio.

Skilled artist's work is generally used to improve the prints and to compensate for the change in tone-rendering that occurs in all processes.

Line Blocks (Zincos). In the simplest form of photo-mechanical process—for the reproduction of originals in line—a negative is first made, *viz.*, with the lines as clear glass and the ground as dense silver deposit. A print is taken from this negative on zinc prepared with a thin coating of a mixture of albumen and ammonium bichromate. In the photo-engraving shop the coating is applied by flowing the zinc plate with the mixture and dried by spinning the plate face down on a hand-whirler with the aid of gentle heat. Printing is done by an arc lamp, the exposed bichromated albumen becoming insoluble in water. The plate is then given a thin coating of a special ink, applied by means of a roller, and developed. This is done by washing in water, which removes the unexposed soluble albumen (and its coating of ink) leaving the exposed, insoluble part with its ink reinforcement. Powdered resin or bitumen is then dusted on, adheres to the ink, and so strengthens the resist image and is fixed thereto by heat. The plate is next placed in dilute nitric acid, whereupon the uncovered metal is etched, leaving the lines standing in relief. In this process the etching fluid, if allowed to act continuously until the etching is deep enough, would attack the sides of the lines, causing weakness of the latter and leading to "brokenness" of the image on the plate. This undercutting is prevented by various methods, one of which is to remove the plate from the etching bath at intervals, to dry, to brush the lines with a fine resin powder (dragon's blood) and to heat the plate, so that the resin forms an acid-proof coating on the sides of the lines. Following certain mechanical treatment, the plate is mounted "type-high" on a wood or metal mount and becomes the familiar line block or zinco.

Half-tone Blocks. For the reproduction of originals of continuous tone, such as ordinary photographs and wash drawings, on metal plates which can be printed with type, the tones of the original are rendered by a system of dots which, by their variation of size in different parts of the picture, give the effect of tones. In the highlights, the dots are of pin-point size; in the mid-tones they are larger, and in the shadows they are so large that they form a solid area of

metal. For this purpose the print on the sensitized metal, which for half-tone blocks is usually copper, is made from what is known as a "screen negative," namely, one obtained by photographing the continuous-tone original through a screen of cross-line pattern. This "half-tone screen" consists actually of a pair of glass plates, each ruled with a series of opaque lines, with alternating clear bands of the same width as the lines, the lines of one plate crossing those of the other at right-angles. Screens of ruling ranging from 65 to 175 lines per inch, according to the quality of the printing paper, are those most commonly used, but coarser and finer screens are occasionally used for special purposes. In conjunction with the stop in the lens, the use of this screen a short distance in front of the sensitive plate in the camera yields a negative which essentially is of the same character as that for a line block; it differs from the latter in having an image consisting of opaque dots of various sizes on a ground of clear glass.

For the explanation of the action of the half-tone screen, the reader is advised to consult the *Ilford Manual of Process Work* or *The Fundamentals of Screen Negative Making*, by W. J. Smith and E. L. Turner, published by the authors.

The copper plate is sensitized, as for a line block, but with bichromated fish glue, and after exposure is washed with water and dyed with a solution of methyl violet to render the image visible. The unaffected glue is then completely removed by further washing, and the plate strongly heated to convert the insolubilized glue image into a hard "enamel" which forms an effective resist.

Etching is done in a solution of iron perchloride, the copper being dissolved where not protected by the enamel dot image. It is by no means an automatic process, for etching is localized by painting parts of the subject with a waterproof ink or varnish, when it is judged that they have been sufficiently etched, and letting the action continue on the rest of the plate. By this "fine-etching" a greatly improved result is obtained from a poor original, though it must be said that excessive fine-etching frequently leads to a departure from the high degree of facsimile reproduction of which the half-tone process is capable.

Line and Screen Negatives. In the early days of photo-engraving the wet plate process* was used almost exclusively for line and half-tone negatives. The improvements made in recent years in the manufacture of process dry plates have led to their extended use, and it is only a question of time before the wet plate will be entirely superseded.

The modern process plate gives a very sharp image of great density, and although there are theoretical reasons for thinking that

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* In which a glass plate is hand-coated with collodion containing iodide, sensitized in a bath of silver nitrate, and exposed in the camera while still wet.

the wet plate is superior in this respect, it is found in practice that negatives made by either method give almost identical results. A higher output of negatives is possible on dry plates in systematic work, and a careful comparison of the cost of working the two methods shows that it is certainly not higher in the case of dry plates, and may in fact be lower if negative paper is used.

The wet plate is insensitive to red and is, therefore, unsuitable for copying coloured originals. The collodion-emulsion process was used in the past for coloured originals, but it is difficult to work, and has been practically superseded by process panchromatic plates.

Line Negatives on Dry Plates, Films, and Negative Paper. Line originals are photographed on Thin Film Half-tone or Process plates, or Line film, which are developed with a developer giving great contrast, such as hydroquinone-caustic, as described in a previous chapter. Backed plates are generally used, and it is usual to "cut" or clear the lines in the negatives with hypo-ferricyanide. Occasionally, with poor originals, it is necessary to intensify afterwards with the mercury-ammonia or the Monckhoven intensifier. Every effort is made to secure a negative in which the lines are quite free from any silver deposit, while the ground must be as dense as possible.

Films are preferred by some operators for this work, a point in their favour being the ease with which several film negatives can be mounted on a sheet of glass for printing-down in one operation.

Photo-mechanical bromide paper, consisting of a process emulsion coated on a thin paper base, is much used for copying the bolder type of line originals, and is cheaper than plates. Paper negatives are exposed, developed, and "cut" in much the same way as plates or films. A slight increase in exposure is required in printing-down, but this may be reduced by making the paper more translucent by treating the back with a suitable solution, such as white wax dissolved in petrol, or preferably a thin mineral oil of the kind used for typewriters.

A special stripping paper is also made, and is of considerable value because of the ease with which reversed negatives can be obtained and because it is not necessary to print through the paper. After development, etc., and drying, the emulsion film may be stripped off the paper and is strong enough to use in this form. It may, if preferred, be transferred to glass. The necessary reversal of image is, of course, easily obtained merely by reversing the gelatin film.

Sometimes it is necessary to reproduce line originals having a black or coloured design on tinted or coloured paper, or to make separate negative records of a design prepared in several different colours. A plate, film, or paper sensitive to the colour to be recorded

must be used in conjunction with a filter which absorbs the colour or colours not to be photographed.

Much work of this kind can be done on Ilford Ortho Photo-mechanical Paper, which is sensitive to green. When red sensitivity is required the Ilford Process Panchromatic Plate is used.

Plates for Screen Negatives. Ilford Thin Film Half-tone Plates or Ilford Process Plates are used for screen negative making. The original subject is illuminated, and the camera is focussed in the usual way. The distance between the screen and plate, and the lens aperture are then adjusted and the exposure is made. It is also necessary to give an additional "flash" exposure of short duration to a sheet of white paper placed in front of the original, to ensure the formation of a dense centre to the dots representing the shadow tones.

After exposure the plate is developed, fixed, and "cut" in the same way as a line negative.

Screen negatives for half-tone block making have firm shadow dots, while the highlight dots join at the corners, forming a slightly closed chess-board pattern. The print on metal from such a negative looks rather flat, and the dots are everywhere larger than they are required to be in the finished block. This is to allow for the reduction in the size of the dots produced by the lateral action of the etching solution during etching. Process films can also be used in the same way as dry plates, and give similar negatives. Coarse-screen negatives can be made successfully and at lower cost on photo-mechanical bromide paper.

Grain Photogravure. In the photogravure process, which is the photographic equivalent of hand-engraving or of aquatint etching, the tones of an original such as a photograph are rendered by the varying depths to which the various parts of the copper plates are etched. The ink is retained in these cavities by thin walls of copper which have not etched owing to the presence of a "grain." The graining is effected by allowing a fine dust of bitumen or resin to settle on the plate and fixing it by heat.

The depth of etching in accordance with the tones of the original is determined by transferring to the grained copper plate a negative carbon print, *i.e.*, a relief image in hardened gelatin made from a positive transparency of the original to be reproduced. It will be understood that the thickness of the gelatin in different parts of this relief is inversely proportional to the tones of the original. Thus, when used as a resist for the etching fluid of iron perchloride, this negative relief allows the etching bath to penetrate to the metal at a rate proportional to its thickness, and thus the metal is etched to depths which are more or less proportional to the tones of the original. Gradation of tone is controlled in this process by retouching on the negative and positive and by the skilled use of the etching

solutions. The rich velvety shadows, good tone values and pleasing surface of photogravure prints from a flat copper plate render the process an admirable one, but it is altogether too slow for commercial use except for a small number of somewhat costly proofs.

Rotary Photogravure. Intaglio printing from copper rollers or cylinders has been practised for many years for textile and wall-paper printing, but it was not until about 1907 that rotary-printed photogravure came into general use, although the well-known "Rembrandt" photogravures were being produced much earlier by a secret process. Copper cylinders are used in the process, and a carbon print is made from the positive, but the copper is not grained. Instead, a cross-line pattern is printed on the carbon tissue by exposure under a special screen. The print is transferred to the cylinder by hand or on a transfer machine, and the stages of development and etching are similar to those in the flat or grain process. The insoluble screen lines of the resist protect the underlying copper in etching, so that small ink-holding recesses of variable depth are etched into the copper.

The cylinder may be of any size up to five or six feet wide by about four feet circumference, and the positives are mounted on glass in the positions they are to occupy on the printed sheet. Type matter in the form of positives, or of direct impressions from type on transparent paper, is inserted where required, and is etched either with the pictures or separately.

A liquid spirit ink is used for printing, and excess ink is wiped off the cylinder surface by means of a flexible steel "doctor" blade. Printing can be effected at a very high speed (up to 30,000 copies an hour), and the ink dries on the paper as fast as it is printed. The process is used extensively for printing periodicals, catalogues and similar work, despite the fact that there is no system of duplication comparable with electrotyping and stereotyping. Recently, thin sheet copper has been used in place of cylinders for rotary printing, and the scope of the process has been much extended in consequence.

Rotary photogravure has some of the qualities of the hand-printed work, noticeably in the depth of the shadow tones and freedom from obvious screen effect. It is not necessarily superior to half-tone for all classes of work, but it certainly gives better results on the cheaper varieties of paper.

Photogravure Negatives. Negatives for photogravure from monochrome originals are generally made on Ordinary Plates.

Coloured originals are copied on Chromatic or Special Rapid Panchromatic Plates, or on Commercial Ortho or Panchromatic Film with a suitable filter. The plates are developed in any good non-staining developer, giving medium contrast, such as metol-hydroquinone.

Photogravure positives are made by contact printing (or by projection if the negatives are non-reversed or not of the right size) Ordinary Plates or Fine Grain Ordinary Films are generally used. Film is particularly useful, when, as is generally the case, several positives have to be cut and assembled for printing together on the carbon tissue.

Colour reproduction is effected in this process by the three-colour method, though a fourth black printing is sometimes added. The process reproduces strong rich colours very well, and it is also excellent for rendering subtle gradation of colour. Accurate facsimile reproduction is difficult, however, chiefly because colour corrections are not made easily after the plates or cylinders are etched. Colour-separation negatives are made through the usual filters on Special Rapid Panchromatic Plates.

Photo-lithography. In pure lithography a design is drawn by hand with "ink" or crayon, which "takes" printing ink on the flat surface of a special form of limestone (litho-stone). But the porous surface of the stone, when damped, repels ink, and thus when the entire stone is damped and then inked with a roller, an image is formed which can be transferred to paper. In this process, zinc and aluminium plates have largely replaced stone and have made possible the use of fast-running rotary litho-printing machines (up to a speed of 5,000 an hour or more), working either directly from the metal on to paper or through the intermediary of a rubber-covered cylinder (offset). This latter method is especially adapted for printing on rough-surface papers and for multicolour printing in bright colours.

In photo-lithography the ink-receptive image on the zinc or aluminium plate is printed by means of a sensitive coating of bichromated albumen, the plate having been previously roughened mechanically so that it will retain a film of water during printing. The sensitive coating is exposed under a line or "screen" negative (see above) of the original, and the plate developed in much the same way as a plate for a line block.

Line originals are reproduced cheaply by photo-lithography, and can be printed on papers that are too rough and hard for block printing. For this purpose, and as a further aid in keeping down the cost, Ilford Photo-mechanical Paper is largely employed. In the case of originals in continuous tone, which are reproduced with the aid of screen negatives, the results usually lack the brilliance of half-tones from blocks, but a "coated" (art) paper is not essential for good printing. Because of the need for remedying defects in tonal quality, especially in multicolour photo-litho, screen positive transparencies have come into use, the dots on them can be reduced by chemical means, this method being somewhat similar to the fine-etching of half-tone blocks. From these positives, screen negatives

can be made and printed down in the usual way, or one of the more modern "positive reversal" processes can be employed. There are also modern methods by which the ink-carrying image is etched slightly and the shallow hole thus formed is filled with ink; these so-called "intaglio litho" plates generally have a longer life on the machine than plates made by the method previously described, and also give slightly brighter prints. This latter method is also known by the ambiguous title of "deep-etch" offset or offset-deep.

Photo-litho Screen Negatives. The method of making screen negatives for photo-litho is essentially the same as that described for half-tone negatives. In photo-litho, however, the dots undergo no appreciable modification in printing-down or in subsequent operations, neither can tonal alterations be made by any process analogous to that of fine-etching. For these reasons a different type of negative is required, to which the distinctive name of "highlight" has been applied. The shadow dots should be slightly smaller than those of a normal screen negative, while the lighter tone dots must be so well joined that no dot is printed on the metal in the extreme highlights. Several methods have been suggested for obtaining this result; the most usual is a system of multiple exposures by which the dots of the lightest tones overlap and form a solid area of density.

Screen Negatives of Colour Originals. Direct screen negatives for monochrome reproduction by photo-litho or half-tone are frequently made from colour originals, including water-colour and oil paintings, as well as brown-toned bromide or carbon prints and similar subjects. In such cases Ilford Rapid Process Panchromatic Plates with an Alpha or Gamma filter should be used.

Collotype. In this process the printing surface is of gelatin, and thus has a very short life in comparison with that of metal plates in half-tone and photo-litho printing. A collotype plate cannot be expected to yield an edition of more than a few thousand. The principle of collotype printing is the selective hardening of the bichromated gelatin produced by exposure through the negative of the original. This hardening limits the amount of moisture which the gelatin film will absorb and thus, according to its degree, allows ink to be retained. The method of treatment of the plate also induces on the surface of the gelatin a reticulated grain which varies in coarseness with the tones of the subject and further assists the ink carrying capacity of the plate.

The printing plate is usually of glass and is first coated with a substratum. It is then flowed with a warm solution of gelatin and a bichromate salt, which is allowed to set on the levelled plate. The latter is then dried in an oven under accurately controlled conditions of temperature and moisture. It is exposed behind the reversed negative to daylight or arc lamps, after which the bichromate is

immersed in a so-called "etch" of glycerine and water which increases the water-absorbent properties of the less-hardened parts of the film and assists them the better to retain their ink-repelling power. Printing is done by rolling the plate with a special stiff collotype ink, and impressions are taken on a hand-press or flat-bed litho machine.

Collotype prints of continuous-tone subjects are distinguished by their fine gradation and freedom from obvious grain, though they lack the depth and brilliance of photogravures. The process may be used for line originals and is very suitable for the reproduction of drawings, etc., in small editions. Its cheapness for short runs is its chief merit, but its slowness in production and its susceptibility to variation in the moisture and temperature of the printing room makes it unsuitable for large editions.

Collotype Negatives. What has already been said in regard to photogravure negatives applies equally to those for collotype. A soft, fully-exposed negative is preferred for daylight printing, and the plates generally used are the Ordinary or Chromatic, or Commercial Ortho Film. For printing by arc lamp or mercury-vapour light a more contrasty negative is required, and may be made by suitable treatment on an Ordinary Plate, or on Fine Grain Ordinary Film. Colour reproductions of the highest quality can be made by collotype, though it is difficult to secure uniform results owing to climatic and other variations. Colour separation negatives are made as for photogravure, though negatives are frequently made for extra printings either through the usual tri-colour filters or through special filters.

Colour Reproduction. Multi-colour printing can be done by any of the processes by means of superimposed impressions in different coloured inks from two or more plates or blocks. Colour-separation negatives are made through the usual blue, green, and red filters for three-colour work, the printing colours being yellow, magenta, and blue-green respectively. A fourth printing in black or grey is frequently added. Colour corrections must be made in each process for various reasons, the chief of which is the departure of the printing inks from the theoretical ideal. In the half-tone process the alterations are made by fine-etching, but in photogravure, photo-litho, and collotype, corrections are made by retouching the negatives or positives, little or no work being done on the printing surface itself. More accurate colour reproduction is possible by half-tone than by the other processes, because tonal alterations can be made to the blocks after proving. On the other hand, photogravure and photo-litho copies are often preferred on account of their surface texture. Photogravure gives exceptionally rich and brilliant colourings with only three printings, whereas additional printings are generally necessary in photo-litho to obtain a similar result. Collotype is

generally regarded as an uncertain process for colour work, but excellent results have been produced by it.

Systems of Colour Reproduction. Originals for colour reproduction are frequently photographed direct, *i.e.*, by making the colour-separation negatives for half-tone or photo-litho through the ruled screen in the process camera, but where this cannot be conveniently done the "indirect" method is used. Continuous-tone colour-separation negatives are made, and positive transparencies made from them. These transparencies, under uniform diffused illumination, are then employed as the originals for the set of screen negatives. This two-step method is sometimes preferred for photo-litho, on account of the ease with which corrections of colour rendering can be made on the intermediate continuous-tone negatives and positives.

A further method, employed for paintings in galleries, outdoor subjects, etc., is to make a screen-plate colour transparency or a colour photograph by a process of photographic colour printing and to make the screen negatives from one or other of these. Even when continuous-tone colour-separation negatives are taken specially for the process shop, a colour transparency or print is a valuable guide to the process etcher or retoucher who may not have the original by him for reference.

Colour-Separation Screen Negatives. Screen negatives for half-tone blocks are made on Rapid Process Panchromatic Plates through red, green, and blue tri-colour filters. The fourth printing in black or grey, often used for improvement of the general effect, is prepared by means of a negative made through a Gamma filter.

A suitable screen angle must be selected for each colour-separation negative to avoid a moiré pattern in the final result. Special screens ruled at the required angles are employed, or a circular screen that can be rotated to any angle is used. The Ilford Screen Direction Indicator is a useful accessory for assisting in setting the screen angles.

Colour Photo-litho. Four-colour photo-litho is used to some extent for colour reproduction, highlight screen negatives being made through the colour-separation filters. There is some difficulty in reproducing pictures having an extended range of tones by this method, and a very exact colour balance must be maintained throughout the work. For these reasons it is frequently customary to make plates for extra colours. These may be drawn by hand or they may be made from negatives taken through special filters. It is more usual, however, to make two negatives of different character through the green filter, and another pair through the red filter.

For the indirect method (see above) colour-separation continuous-tone negatives are made through the usual filters on Special Rapid

Panchromatic Plates. These are developed to a moderate degree of contrast, then contact positives are made on Ilford Ordinary Plates; after the necessary retouching, the final screen negatives are made on Ilford Process Plates.

Plates for Photo-litho Screen Positives. The difficulty of making tonal corrections in the ordinary photo-litho process has led to the development of a special technique in which screen positives are used. Corrections can then be made on the positives by altering the size of the dots by chemical means. The positives may be made on Process Plates by contact from screen negatives. Alternatively, ordinary or colour-separation continuous-tone negatives are made on Ordinary or on Special Rapid Panchromatic Plates, and screen positives are made from these on Process Plates. Litho plates are made from these screen positives by the "positive reversal" or "intaglio litho" methods, full details of which cannot be given here.

CHAPTER XXI

PHOTOGRAPHY APPLIED TO PLAN COPYING IN THE ENGINEERING AND OTHER INDUSTRIES AND TO THE COPYING OF BUSINESS RECORDS GENERALLY

The term "document copying" can be applied to a wide variety of different types of work. Engineers and architects are specially interested in the copying of plans and drawings, and have learnt to think chiefly in terms of engineer's blue-print papers or dyeline papers, while office organizations, interested in the duplication of letters, etc., are already acquainted with the advantages of photographic copies made in a special camera fitted with a reversing prism to give negative images on paper which are the correct way round for reading.

The applications of the various copying methods in use overlap considerably, but the advantages of these methods based on the use of light-sensitive silver salts—generally regarded as truly photographic, as distinct from the blue-print and similar processes—are rapidly becoming more widely recognized by progressive firms, with the result that the installation of a photographic department is being found to be a useful and profitable investment. These advantages may be summarized as follows:—

(1) Elimination of manual copying by typing or tracing.
(2) Elimination of checking, since photographic methods cannot introduce textual errors.
(3) The possibility of increasing the density and firmness of the lines of a drawing, thus producing from a pencil drawing a result equivalent in quality to a tracing.
(4) The reproductions can be made to any convenient size or to several sizes suitable for different purposes. It is frequently convenient to have an original drawing made large, copies for workshop use about half size and those for office reference considerably smaller.
(5) The problem of the storage, preservation and classification of large numbers of big drawings can be eliminated by storing small reproductions in card index files. In fact, there is no loss if the original drawings are destroyed as duplicates can be made in the photographic department as and when required from the file of reduced negatives.
(6) Similarly, office records and archives can be copied on to micro-film in such a way that the negatives occupy only a fraction of the original space and yet can be reproduced in convenient size whenever required.

(7) Photographic reproductions have the advantage of being less inflammable than ordinary paper. If on film they should always be on non-inflammable (acetate) base and in the case of paper prints the emulsion coating on the surface reduces the inflammability.

(8) A photographic system can offer a better insurance against loss of essential records by war or fire risks than any other method.

The object of this chapter is to give a brief introduction to the various reproduction processes which are in use to enable those interested to select the technique most likely to suit their own particular requirements. Since all these methods are based on the use of light-sensitive materials of the same general class, there are certain fundamental points concerning the handling of these materials which should be understood. In the first place, nearly all of them are of sufficient speed to necessitate handling in a specially equipped darkroom, the exception being Reflex Paper. Suitable illumination can easily be provided in the darkroom by placing the lights behind the recommended "safelights" in specially made lamps. After exposure, the sensitive materials need development to produce a visible image, and this must be followed by fixation to remove the unused silver and then by a thorough wash to ensure permanence. Anyone experienced in developing roll films and making gaslight prints will have sufficient working knowledge of the precautions necessary and can handle any of these processes.

The recommended development formulæ and times of development are given on page 386, but it is important to remember that sufficient solution should be used to give at least one inch of developer in the dish, that the sensitive surface should be slid under the solution quickly and in such a way as to avoid air-bubbles on the surface, that if more than one sheet is in the developer at a time the prints should be moved from bottom to top continuously, that at the end of development they should be given a quick rinse in clean water and passed to the fixing bath where again agitation or circulation of the prints is necessary, particularly in the early stages. After fixing, which should never be for less than 5 minutes, even when the bath is fresh, and should preferably not be for less than 15 minutes, the prints should be given a thorough wash in running water for about half an hour. Where several prints are being washed together it is not sufficient to leave them as a solid wad in the water, but they should be constantly separated and turned over by hand.

The following table lists the various photographic products that are most likely to be useful in the copying methods to be referred to, and for convenience the relative speeds, recommended developers and development times, are summarized in the same table.

Product	Relative Exposure to Half-watt Light	Colour Sensitivity and Safelight	Recommended Developer	Development Time at 65°F. (18°C.)
Document Paper No. 50 (Reflex Paper)	Very slow — for contact use only	Yellow Sensitive Safelight VS (No. 901)	ID-36	45 secs.
Ultra-Contrasty Glossy Bromide Paper, S.W. (B.6.1P)	140	Blue Sensitive Safelight S (Light Brown) (No. 902)	ID-36	2 mins.
Document Paper No. 55	50	Blue Sensitive Safelight S (Light Brown) (No. 902)	ID-36	1½ mins.
Document Papers Nos. 1, 4 and 4T	1	Highly Ortho-chromatic Safelight Iso (Red) (No. 906)	ID-36 or Document Developer in tins	45 secs.
Photo-mechanical Paper	50	Blue Sensitive Safelight S (Light Brown) (No. 902)	ID-36	1½ to 2 mins.
Ortho Photo-mechanical Paper	15	Ortho-Safelight Iso (Red) (No. 906)	ID-36	1½ to 2 mins.
Orthotrace	25	Ortho-chromatic Safelight Iso (Red) (No. 906)	ID-36	1½ to 2 mins.
Line Film (non-inflam-mable)	30	Slightly ortho-chromatic Safelight S (Light Brown) (No. 902)	ID-36	3 to 4 mins.

SUMMARY OF REPRODUCTION PROCESSES AND THEIR USES

(1) **Same Size Reproduction.**

A. Contact Copying. When originals are on clean paper and have no writing on the back, it is quite simple to make contact negatives on to any suitable photographic material, probably the best being Ilford Ultra-Contrasty Glossy Bromide Paper, single weight. If a thinner and more transparent base is required Ilford Document Paper No. 55 can be recommended. These negatives are reversed from left to right, and so are not easy to read, but from them positive prints can be made quite easily in a similar manner. The chief difficulty is keeping the original and sensitive material in sufficiently good contact. In the case of large drawings the use of a vacuum printing frame is essential.

This method is not satisfactory with blue-prints.

B. Reflex Copying. In this process negatives are produced on a special paper—Ilford Document Paper No. 50 (Reflex Paper) which

is placed in contact with the original and exposed through the back of the sensitive paper and not through the original as in method 1*A*. A special leaflet can be supplied giving further details, but the only important points are that it is usual to use a special yellow filter—the Ilford Reflex Filter—over the light source, and that with large drawings the use of a vacuum printing frame is desirable to obtain adequate contact. Reflex Copying is of particular value when there may be writing on the back of the drawing so that it is impossible to print through, but it will be realized that the resulting negative will be reversed from left to right and so cannot be read easily; it is therefore necessary to print a positive. In the case of blue-prints, quite satisfactory reflex negatives can be obtained, but since in this case the original is white on a blue ground, the negative obtained is really a positive, *i.e.*, black lines on a white ground. Such an image is very suitable for passing through a blue-print machine for making further duplicates, the surfaces of the negative and of the blue-print being placed in contact. The machine must be run at its slowest speed.

C. Where not more than one copy is required, and the original is on one side of the paper only, it is quite simple to make a contact negative, as above, by placing either the original or the sensitive paper the wrong way round so that the resulting negative is not reversed and so can be conveniently read without the necessity to make a positive. Where the original is a blue-print, the same procedure gives a positive the correct way round but, as indicated under 1*A*, the result is not likely to be very satisfactory unless a special technique is used, as follows. Place the blue-print with its base towards the source of light and the Reflex Paper with its base to the blue-print image, so that the exposure is made through the base of the Reflex Paper. Next place a sheet of smooth, opaque white paper in contact with the emulsion surface of the Reflex Paper and keep the whole in good contact in a vacuum printing frame. After exposing and developing in the usual way an excellent positive, the correct way round for reading, is obtained on the Reflex Paper. It is immaterial whether the Reflex Filter is used or not. Although this arrangement is recommended only when a single copy is required, further copies can be made on the blue-print machine from this positive in the usual way, but the blue-prints are not so good as those obtained by the method *B* above.

(2) **Reduced Reproductions.** When it is desired that reproductions shall be a different size from the original, it is of course essential to use some form of camera. An ordinary camera negative, besides representing any white area as black, also reverses the picture from left to right, so that the negative image cannot be read conveniently. By placing a prism over the lens the image can be reversed again so as to be the correct way round for reading; consequently the special

document-copying cameras employed for this work are normal cameras provided with a prism and also with a convenient device for holding the rolls of paper on which the exposures are made. Each exposure is then cut off and developed, the cameras frequently incorporating a semi-automatic developing system. Special papers are made for use in these cameras, of which the following are the most important:—

Ilford Document Paper No. 4—coated on a standard grade of paper which is fairly thick and strong.

Ilford Document Paper No. 4T—a similar material on a much thinner base paper, which is convenient where the copies have to be sent through the post; it is also more convenient when it is desired to pass these negatives through the blue-print machine.

Ilford Document Paper No. 1 is a similar material on a special all-rag base paper, between Nos. 4 and 4T in thickness, particularly made for the use of librarians who may wish to ensure their copies keeping for very long periods, such as over 100 years.

Where one copy only is required it is usual to make use of the negative image because it can be read quite conveniently, while duplicates are made by re-photographing this negative in the same camera the appropriate number of times to give the required positives.

Although these special document-copying cameras are usual, they are not necessary if more than one copy is required, because the reversed image obtained in the camera is re-reversed again during the copying operation. The negative can be made in any camera without the use of a prism and the positives made by re-photographing or by contact printing through the negative.

Document Papers Nos. 1 and 4 have very high-speed emulsions and are orthochromatic, that is, sensitive to yellow light, and when used in conjunction with a yellow filter are excellent for photographing blue-prints. For the engineer copying intricate plans there is a distinct advantage in employing in place of the usual document papers, the more expensive Ilford Photo-mechanical or Ortho Photo-mechanical Papers, as these are capable of giving cleaner and stronger lines than would normally be obtained on a document paper.

Having made the best negatives from the plans on Photo-mechanical Paper, it is preferable to make the positive by contact on Ilford Orthotrace, which has a transparent base somewhat similar to tracing linen. These positives can be looked upon as tracings, with the advantage that they can be smaller than the original; they are entirely suitable for passing through the blue-print machine at the normal speed to produce further economical reproductions.

(3) **Reduced Negatives for Subsequent Enlargement.**

A. A particularly useful system has been introduced in which all plans are photographed to a much reduced size, usually on to sensitive material of size $6\frac{1}{2} \times 4\frac{3}{4}$ in. for all drawings up to 40×30 in. In the case of larger drawings containing much detail it may be preferable to make the negatives on a larger scale.

For the best quality results these negatives should be on Ilford Line Film, but they can be made in any convenient type of camera, provided the lens is of good quality. For greater economy Ilford Orthotrace may be used as the sensitive material.

These negatives are stored in transparent paper envelopes in filing cabinets and make an ideal and compact record of the whole of the work of the drawing office. Since the film employed is non-inflammable, the dangers attendant on the storage of celluloid do not exist. Very frequently two sets of negatives are made, one for regular use and the other for storage elsewhere as a precaution against any possible loss or damage to essential records. In addition, contact prints from these negatives on Ilford Extra Contrasty Glossy Bromide Paper, single weight or double weight, make very convenient records for reference in the office and estimating departments.

From these negatives enlargements are made in any suitable photographic enlarger on Ilford Orthotrace. Obviously the enlargement may be the same size as the original, but is very frequently made smaller, as this represents a considerable saving and is generally considered more convenient. The Orthotrace enlargement corresponds exactly to a hand-made tracing, but requires no checking, as there is no possibility of human error being introduced. From these enlargements blue prints or Diazo prints are prepared in the usual way.

B. Alternatively, some workshops prefer their drawings in the form of black lines on white ground rather than in the form of blue-prints. In these cases the reduced negative is enlarged up on to Ilford Document Paper No. 55, the required number of positive copies being prepared at one time. Although a little more expensive, these positives are definitely preferable to blue-prints, can usually be made appreciably smaller and yet be equally legible and are more convenient for use in the office and for dispatching with correspondence.

C. A more economical development of the same system is to make the reduced negatives in the form of opaque images on paper, the best material for this purpose being Ilford Ultra-Contrasty Glossy Bromide Paper, single weight or double weight. On this material any good quality drawing up to 30×40 in. can be reduced to $6\frac{1}{2} \times 4\frac{3}{4}$ in. and the negative so obtained is, of course, ideal for storage.

To obtain the enlarged positives from these negatives they are re-photographed in a suitable type of camera on to Ilford Document Paper No. 55, which gives entirely satisfactory reproductions of any required size. If a large number of duplicates is required the positive on Document Paper No. 55 can be passed through the blue-print machine run at its lowest speed or, alternatively, the positive could be made on Orthotrace, when the greater transparency of base allows the blue-print machine to be run at its normal speed.

(4) **Micro-copying Methods.** It has been recommended to make micro-negatives of all plans on film 35 mm. wide so that the resulting negatives can be conveniently stored in a very small space as an insurance against loss by fire or other damage. Ilford Limited make two special films for this type of work, but the degree of reduction necessary to bring a large drawing down to this size is very great, and should it be necessary to reconstitute original drawings from these micro-negatives some difficulty is sure to be experienced in obtaining sufficiently good results, even assuming that the work has been done in the best possible manner; therefore, although micro-copying is ideal for reproducing written or printed records and archives, it is not specifically recommended for use in plan copying, and the method recommended under heading (3) is preferable.

Micro-copying methods are particularly valuable where business records and such like documents are concerned and in this connection the use of narrow width films (35 mm. or 16 mm.) has a very extensive application. Micro-copying is an operation which can be undertaken by any business house which is prepared to equip a small darkroom and to employ one or more skilled operatives. Alternatively, Ilford Limited offers a confidential micro-copying service and members of the Ilford staff will, if required, carry out the actual photography on the customer's premises.

THE TECHNIQUE OF MICRO-COPYING

Apparatus

Special apparatus which has decided advantages in speeding up the photography has been designed for the work, but its use is by no means essential, since excellent results can be obtained with the aid of any of the better quality miniature cameras. With these the principal difficulty is in focussing for perfect sharpness of image which is essential for satisfactory micro-copying. Since focussing by scale alone is not usually sufficiently accurate, miniature cameras of the reflex type are strongly recommended, or those for which special focussing or copying devices have been marketed.

In the case of 16 mm. film, certain makes of ciné cameras which are capable of taking one exposure at a time may be employed, provided that film of sufficiently high quality is used.

Ilford Micro-copying Films

Most of the high-speed films sold for use in miniature cameras or for cinematography are lacking in sufficient contrast, and are too coarse grained for really good quality micro-copying. It will be realized that very high-resolving power is essential if small printed or written characters are to be reduced by many diameters in a negative which must be suitable for re-enlarging to the original size.

Some of the subjects to be copied may be in more than one colour and many records are on paper ruled with faint blue lines. In such cases panchromatic emulsions must be employed for the best results.

To meet the above requirements the following special films are recommended.

Ilford Micro-Neg Film (Panchromatic)—has an exceedingly fine grain, yields a high contrast and is specially recommended for all best quality work.

Ilford Diapositive Film (non-colour sensitive)—suitable for work where the degree of reduction is not excessive and the original is in black and white only—also for making positives from existing negatives.

Ilford F.P.2 Film (Panchromatic)—a fast film of fine grain but relatively low contrast which may be used in cases where short exposures are essential. It is specially suitable for copying photographs and half-tone reproductions.

35 mm. film is not supplied in lengths of less than 100 ft.

In the absence of specific instructions films are sold unspooled, without leader or trailer, and reeled with the emulsion in, but in order to fit the various special cameras, can be supplied on request wound on spools either emulsion in or emulsion out, and with or without leader and trailer. It is important when ordering to state the type of winding required or the make of camera in which the film will be used.

16 mm. film is supplied on the usual 50-ft. or 100-ft. spools.

Degree of Reduction

The scale of reduction to be recommended naturally depends on the size of the lettering in the original, the shape of the page, and the use to which the negative is to be put. In the case of printed matter it is possible to make accurate recommendations by referring to the point size of the type employed. For instance, newspapers are usually in 7 point type (6 point in financial columns) while novels average 12 point. One point is equal to 0·0139 in. (1/72 in.). Experience has shown that the type should not be reduced in the micro-negative to a size below the equivalent of 0·4 point (40 centipoints) so that the maximum permissible reduction factor for a newspaper is $17\frac{1}{2}$, and for a novel, about 30. These figures refer to Micro-Neg Film.

The corresponding factors for reduction on Diapositive Film, which is not so fine grained, are about one-half these values. It must be understood, of course, that in all cases the smaller the amount of reduction which can be used the better will be the resulting negatives. As a safe working rule a maximum reduction factor of 18 should be applied to general commercial records on Micro-Neg Film.

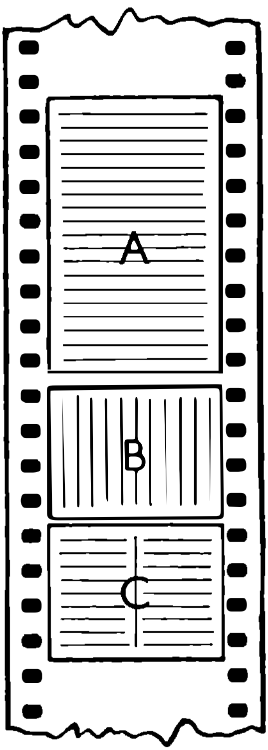

Fig. 107.

Arrangement of Subject

For 35 mm. film three arrangements of the subject are recognized:—

Format A.—Image 36 × 24 mm. (Leica frame size), the lines of type of an average page being at right-angles to the length of the film.

Format B.—Image 24 × 18 mm. (Ciné frame size), the lines of type being parallel to the length of the film.

Format C.—Image 24 × 18 mm., but with two pages per ciné frame, arranged with the lines of type at right-angles to the length of the film.

The maximum sizes of originals suitable for reduction to each format when using Ilford Micro-Neg Film with special fine grain development are given in the following table, but when possible it is preferable to limit the originals to half these dimensions.

Format A

Newsprint 24 × 18 in.
Advertisements and plans (not less than 12 point type) 40 × 30 in.
Intricate machine drawings 27 × 18 in.

Format B

Newsprint 18 × 12 in.
12 point type 30 × 20 in.
Intricate designs 18 × 12 in.

Format C

Book pages 18 × 12 in.

The frame of a 16 mm. film is approximately 10·5 × 7·5 mm., and it must be realized that large documents cannot conveniently be

reduced on to film of this size. Applying the recommended maximum reduction factor of 18, it will be seen that the largest original which will give good results is about 7 × 5 in., except in cases where the type is large. Thus, it is possible to reduce matter from a normal typewriter using 10 × 8 in. sheets on to 16 mm. film, and still greater reductions may be satisfactory if it is only intended to use the negatives in viewing apparatus; in the latter case, however, re-enlargement to the original size is likely to be disappointing.

Precautions prior to Exposing

When setting up apparatus for micro-copying, it is necessary first to obtain an approximate focus and then to ensure that the whole of the subject is included in the picture area. This is best achieved by visual examination on a focussing screen; otherwise it must be settled by measurement and the use of appropriate tables, if available, or by trial and error.

Care must be taken to see that all the originals lie perfectly flat and that they can all be placed in turn in the correct position. In general, a light grey card constitutes the best background on which to place the document for copying, because it ensures that the outlines will show up well. On the card, lines can be drawn in pencil marking the corners of the document, to which all subsequent sheets can be positioned. Alternatively, strips of card may be stuck in position to form stops against which to lay the pages. If the documents vary in size and shape they must, of course, be reproduced at such a scale of reduction that the largest of them appears complete on the negative. When large numbers of exposures are to be made it is impossible to keep re-focussing the camera.

When the originals show a tendency to curl or have been badly creased, a sheet of glass of sufficient size should be placed over them and hinged by means of a strip of adhesive tape at the back so that it can be lifted up to change the originals. This glass should be in position before the final focussing operation. Special book-holders are made for keeping the pages of books flat and are practically essential if much of this work is to be done.

Focussing must be accurate and if possible the parallactic method should be employed. For this, very fine cross lines must be ruled on transparent portions of the ground-glass screen. After the image has been brought to a focus by direct observation it should be viewed through a magnifier, the head being moved backward and forward and from side to side as far as possible, while still keeping the image in view. So long as the image appears to move in relation to the cross lines, the focussing is still inaccurate and must be adjusted until this relative movement disappears.

The lighting should be carefully adjusted to ensure even illumination, while at the same time it is essential to avoid direct reflection of the lights from the copy into the camera lens. Should such

reflections be apparent, the lamps must either be lowered or moved further out from the camera support. When copying glossy surfaced matter reflections are particularly troublesome.

In cases where glass is placed over documents, as, for instance, with creased originals which have to be kept flat or where a bookholder is being used, reflections are again easily produced, and it may be necessary to dull or cover all chromium parts on the camera or stand. Similarly, the operator should not wear a white overall or dustcoat.

As far as possible, the lights should be kept in a fixed position because every time they are moved the exposure must be redetermined. It is an advantage to place the lamps comparatively low and sufficiently far apart to illuminate evenly any reasonable size of original; this will obviate frequent readjustments and allow the exposure to be determined without unnecessary waste of time. Suitable illumination is given by two 500-watt lamps or four 100-watt lamps in reflectors.

Deciding on the Correct Aperture

Many of the lenses used in micro-copying have apertures as large as *f*/3·5, but for this class of work they should never be used at the full aperture. With some of them the best resolving power will be obtained at about *f*/6·3, but it is also essential that the image shall be evenly exposed and equally sharp from the centre to the corners. This is difficult to achieve except at a relatively small aperture, so that it is unusual to work at a larger aperture than *f*/8, and for critical work or with large originals it is necessary to stop down even further to about *f*/16. Smaller apertures than this usually show little advantage and may lead to loss of resolving power. Since micro-films are comparatively slow, it follows that powerful lights are necessary and that short exposures cannot be used when the best results are required. The final decision as to the correct aperture to use can only come from experience with the particular lens and camera employed.

Determining the Correct Exposure

The correct exposure must be determined by trial, and should be such that with the development conditions chosen, a black line appears on the negative as a clear line without veil when the dry film is viewed by placing it in contact with a sheet of white paper. Under the same conditions the white of the original should be reproduced as an opaque black. If the lights are kept in the same position, all subsequent exposures will be comparable, provided allowance is made for the following points:—

(1) For normal reduction factors (between 1/8th and 1/12th), variation in the degree of reduction does not affect the exposure.

(2) At great reductions the exposure must be increased slightly. With a reduction factor of 1/20th, for instance, the exposure should be increased by approximately one-third.

(3) At small reductions, increase of exposure is also necessary. Thus, with a reduction factor of one-quarter, the exposure should be approximately doubled.

(4) When the lens aperture is opened, the exposure is halved for each subsequent stop size marked on the lens ring. Thus, if the exposure at *f*/16 is known and the lens is opened to *f*/11, the exposure will be halved, and with a further opening to *f*/8 will be reduced to one-quarter.

(5) Increasing the distance of the lamps from the copy lengthens the exposure, the increase being a little less than in proportion to the square of the distance from the centre of the lamp to the centre of the copy.

(6) If certain fine-grain developers are to be used, it may be necessary to increase the exposure up to as much as double the time required when using the ID-2 formula recommended in the next section.

The exposure tables provided in Chapter VI will be found to give a fairly close approximation to correct exposure. They should be used to arrive at the first estimate, and this estimate should then be corrected by trial.

Copying Coloured Originals

Objects which are purely black and white can be photographed with equal ease on any of the three recommended films (see page 391). Coloured objects require, of course, one of the panchromatic varieties, the colour sensitivities of which are so well balanced that in cases where the colouring is not very bright or pronounced, entirely satisfactory copies can be made directly without the use of colour filters. When, however, colour is a vital part of the subject, reproduction can often be improved with the aid of a filter, which, if appropriately chosen, will assist in rendering the coloured details as clear areas in the negative, sharply contrasted with the background. Similarly, in cases where the background itself is tinted, legibility can be greatly increased if a filter is chosen which will reproduce this background as an opaque area in the negative, that is to say, as white in the final enlargement.

The choice of a filter depends, of course, on the colours present in the subject, and the reader will find full information about their use in Chapter IV. For micro-copying a set of four filters will meet most requirements, and their selection, as indicated in the following table, is quite simple. The necessary exposure factors are given in the second and third columns for ordinary incandescent filament or photoflood lighting.

EXPOSURE FACTORS

Name of Ilford Filter	Ilford Micro-Neg Film		Ilford F.P.2 Film		Colour of details to be stressed by recording as clear on the negative	Colour of background to be eliminated by recording as black on the negative
	Gas-filled lamps	Photo-flood lamps	Gas-filled lamps	Photo-flood lamps		
Tricolour Red (No. 204)	3	4	2½	2½	Green	Red Mauve Orange
Tricolour Green (No. 404)	5	4	8	7	Red Orange Mauve	Green
Tricolour Blue (No. 304)	40	25	15	10	Yellow	Blue Violet
Delta (yellow) (No. 109)	1½	1½	1½	1½	Blue Violet	Yellow

Development

Where films are exposed in a miniature camera they can, of course, be developed in the usual type of developing tank, but for 100-ft. lengths special apparatus is necessary. This is not easily obtainable and it is recommended, therefore, that films should be sent to Ilford Limited for processing. A detailed price list is obtainable on request. For those who wish to do their own processing, the recommended conditions are given below.

It is necessary to take into consideration the use to which the resulting negatives are to be put. If they are for viewing in a micro-film viewer, or for any other form of visual examination, a high contrast is an advantage, but where the films are being prepared with a view to the making of paper enlargements, either immediately or at some subsequent date, then development should be shortened to produce negatives of relatively soft gradation. In cases where the originals are very irregular as, for instance, where parts of the lettering are black and parts grey, then a short development will again give the best results.

Any well balanced M.Q. developer can be used, the Ilford ID-2 formula being entirely satisfactory:—

ILFORD ID-2 DEVELOPER

Metol	.. 20 gr.	or	1 g.
Sodium sulphite (cryst.)	.. 3 oz.		75 g.
Hydroquinone	.. 80 gr.		4 g.
Sodium carbonate (cryst.)	.. 2 oz.		50 g.
Potassium bromide ..	.. 20 gr.		1 g.
Water, up to	.. 20 oz.		500 c.c.

This should be used at the usual dish development strength, consisting of one part of the above developer diluted with two parts of water. At a working temperature of 65°F. (18°C.), the recommended development time for Micro-Neg or Diapositive Films is 6 minutes when the negatives are intended for visual examination, and 4 minutes if for enlarging purposes or when the originals are irregular and of generally poor quality. When using F.P.2 film, 9 minutes development is suitable.

Ilford ID-2 Developer can be supplied in powder form ready for dissolving, and is sold in convenient packages.

Fine Grain Development

Since the emulsions used for micro-copying are specially chosen to have the finest possible grain size, the advantage to be obtained from the technique known as fine grain development is less than in the case of the faster emulsions used in ordinary photography. With most commercial micro-copying the advantage is generally negligible but in cases where the reduction factor is large and emulsions are being used near the limit of their resolving power, fine-grain development may be used with advantage.

Any of the well-known fine-grain developers can be employed but many of them will necessitate increased exposure, and the correct development time will have to be found by trial.

Fixing

The films should be fixed in an acid fixing bath. There is, however, an advantage in using one which is also a hardening bath and the following formula is recommended. It should be noted that the minimum time for satisfactory fixation is 3 minutes.

Hypo	12 oz.	or	300 g.
Sodium sulphite (cryst.)	350 gr.		20 g.
Boric acid	87 gr.		5 g.
Glacial acetic acid ..	192 m.		10 c.c.
Potash alum (cryst.) ..	½ oz.		12·5 g.
Water, up to	40 oz.		1000 c.c.

Note on the preparation of the Acid Hardening-Fixing Bath.

The hypo should be dissolved in about one-half of the final volume of *warm* water. The sulphite and boric acid must next be added and completely dissolved. The solution, if still warm, should then be cooled to 70°F. (21°C.), and the acetic acid, diluted with about four times its volume of water, poured in while the bath is being continuously stirred. The alum should be dissolved separately in about one-fifth of the total volume of warm water and the resultant solution added, after cooling to 70°F. (21°C.), to the rest of

the ingredients, stirring all the time. The total volume is finally adjusted by the addition of more water.

N.B.—It is important that the acetic acid should be diluted in a vessel free from traces of hypo, as this acid readily causes sulphurization when added to hypo in the absence of sulphite.

Washing and Drying

Very thorough washing is necessary if the resulting negatives are to be really permanent. Running water should be used and several complete changes may be given with advantage. No matter what method is used for drying the film, it should first be carefully wiped to remove surplus moisture. A good quality viscose sponge, which has been slit down the middle so that the film can be slipped inside, is ideal; it should be well soaked and then not too thoroughly squeezed out. Films which have been hardened during fixation are much easier to wipe without scratching.

Positive Copies

In many of the cases where micro-copying is employed the negative is all that is required, because it can be stored away in safety and is only needed should the original document be damaged. Occasions arise, however, where a number of duplicates of the micro-negatives are required, as, for example, in library work when it is desired to send micro-copies of books to other libraries while retaining the original negative. The most economical method is to have positive copies printed from the micro-negatives on to Ilford Diapositive Film.

Printing individual positives by contact is quite a simple operation, but where long lengths of film have to be printed, special apparatus is required. Such work can be undertaken by Ilford Limited.

Enlargements on Paper

When it is desired to reconstitute the original from the micro-negative, it is only necessary to make enlargements on a suitable paper in the normal manner. Any high-class miniature enlarger is perfectly satisfactory for this work and no special instructions need be given.

The most suitable sensitive paper for the enlargements is Ilford Document Paper No. 55, which is coated on a base of convenient thickness which can be folded without cracking.

Bromide paper may also be used successfully and provides a wide choice of surfaces. Ilford Light Weight Bromide Paper will be found especially convenient in many cases and is available in the three contrasts, soft, vigorous, and extra contrasty; for the majority of negatives the extra contrasty paper will prove most suitable.

Filing Micro-Negatives

Where the records have been made purely as a precautionary measure, and are not to be used except in an emergency, they are best stored in 100-ft. rolls in tins appropriately labelled. In libraries, where whole books are duplicated on film, storage in complete rolls is again generally the best method of filing. Where, however, numerous individual subjects are photographed and the records may be required at frequent intervals, it is usually best to cut the films up into appropriate short lengths and file them in specially made envelopes or in loose-leaf pages held in binders. Full references to each subject can then be entered on the outside of the containers and the whole indexed. Several excellent filing and binding systems specially designed for this and similar purposes are now on the market.

CHAPTER XXII

COLOUR PHOTOGRAPHY

The production of pictures in colour by purely photographic methods has held the attention of inventors and investigators almost since photography came into existence. To-day transparencies in colour can be produced easily and very satisfactorily by several processes, but prints in colour to be viewed by reflection can even now be prepared only with some difficulty and by the exercise of considerable patience and skill.

All present-day colour processes depend upon the preparation of either two or three separate records, each one telling part of the story in terms of a certain colour range and upon a subsequent reassembling of the records in visual coincidence. Two-colour processes can give but a fairly poor approximation to correct rendering.

Without going into detail it may be accepted that practically all colours found in nature may be matched by a mixture of three primary colours which between them embrace the entire visible spectrum. A great deal of research has been carried out to determine how best to divide the spectrum into three for this purpose, but it will be sufficient to consider how the separation is effected in practice and how the complete multicolour picture is formed again. The analysis filters will be described as red, green, and blue.

The simplest case is represented by the colour-screen processes, of which there are several examples. Here the separate colour records are formed on the one plate or film, the sensitive material is processed by the reversal technique to give a positive, and a transparency in full colours is at once available.

In these processes the separation filters, red, green, and blue, take the form of innumerable small elements scattered at random (Autochrome) or, in regular order (Dufaycolor, Finlay Color) over the surface of a plane immediately in front of the sensitive emulsion surface and each element acts as a separation filter for that part of the emulsion layer lying immediately behind it. So the complete green record is built up of all the little areas lying behind the green elements, similarly the red record is built up of all the little areas behind the red elements and the blue record of the areas behind the blue elements.

Now if the plate or film processed to a *positive* is held up to the light with the same multi-element screen in exact register, light will be transmitted wherever there is no silver deposit, *i.e.*, wherever the negative image was situated and that, of course, means wherever light was active in the first place. So if the image of a red patch fell upon a certain area of the emulsion the light would be transmitted

by all the little red elements, but not by the blue and green. In the processed positive there would be no silver in the area behind the red element, but there would be silver behind the blue and green, and so on holding the plate and screen in register only red light would come through; it would come through all the little red elements over the area of the patch of red image. These elements are so small that the eye perceives no discontinuity, but only a red patch corresponding exactly to the red original. The same thing applies to green and blue patches. Black patches on the original result in silver occurring all over the corresponding area in the developed positive and so no light comes through. White areas on the original are represented in the developed positive by areas in which no silver occurs behind any of the elements, red, green, or blue. Light is transmitted by all three sets of elements the eye does not see, red, green, and blue separately, but the three together, *i.e.*, white light. This is an example of additive synthesis, *i.e.*, all the various colours produced are the result of the mixing of two or three coloured lights.

A similar synthesis could be achieved by taking the three records, each through the appropriate filter, on separate plates, and projecting the developed positives, each through its taking filter, in register on a screen. The additive method cannot be used when the several images are superimposed—the ingenuity of the screen plate processes lies in the fact that the three records are really adjacent to each other, the broken nature of each image allowing all three to be woven together.

It is clear that in the additive method black silver images and coloured lights are considered, but in the subtractive methods consideration is given to coloured images which may be superimposed one upon another.

Take again the three separate negatives produced through the red, green, and blue filters respectively and make positives as before, but instead of examining them through coloured filters, actually change the silver images into images in transparent colours—that taken through the red being dyed blue-green, that through the green, blue-red (magenta) and that through the blue, red-green (yellow). These colours are, in fact, complementary to the original taking filters and are themselves called primary colours by artists who refer incorrectly to the magenta as "red" and to the blue-green as "blue."

Now if the three coloured positives are superimposed in register, the result will again be a more or less faithful representation in full colour. In this case white is represented not by a mixture of red, green, and blue light, but by absence of any image, *i.e.*, complete transparency. Red is represented by yellow and magenta superimposed—between them these colours absorb blue and green and transmit only red. Blue is produced by blue-green and magenta super-

imposed—which between them absorb everything but blue, and green by yellow and blue-green superimposed—which together absorb everything but green. Blacks are obtained where images in all three complementary colours are superimposed. Such a composite coloured positive may be projected in the lantern or made to adhere to a paper base to be examined by reflection.

The subtractive method, therefore, depends on the fact that each separation-image colour reflects two-thirds of the spectrum, while any two image colours superimposed reflect one-third, the reflections which remain after superposition of the images more or less faithfully representing the colours of the original. The subtractive process may be used for the making of transparencies or prints on paper.

The various systems differ, of course, in the manner in which the separation negatives are produced and also in the way the positive images are transformed into coloured images. Kodachrome and Agfacolor are both subtractive processes in which the separate colour records are carried one upon the other on one film. Both processes employ colour development, *i.e.*, colour is produced by interaction between special colour-forming agents and the (oxidation) products formed at the points where development is proceeding. In the original Kodachrome the colour-forming agents were present in the processing solutions; in Agfacolor they are present in the emulsion layers, special care being taken to prevent diffusion from one layer to another. Thus with Agfacolor one final developing bath produces three differently coloured images. With the Kodachrome process as first introduced the first step was to colour all three parts of the positive image alike. Then a bleach bath was allowed to discharge the two top layers. A second developing bath coloured the two top layers and then the topmost was bleached to be transformed finally into the third colour.

The Agfacolor and Kodachrome processes just described employ reversal development. More recently in the Kodachrome process the differential bleach technique has been discarded and the coloured positive produced by three separate exposures each followed by a process of development. After development of the negative image, and without removing it, the film is exposed through the base to red light and the latent image produced is developed with a colour-forming developer to give a blue-green image. Next, the film is exposed to blue light from the front and development follows to give a yellow image. Finally, the rest of the silver bromide, *i.e.*, that in the middle layer, is exposed and developed to give a magenta image. Then all the silver is removed. Colour prints on white opaque film base can be made from Kodachrome originals.

A further development by the Kodak Company employs what has been termed a "protected coupler" process in which, as in the Agfacolor process, the coupling agents are present in the sensitive

material. In the new Kodak process, called Kodacolor,* the couplers are carried in small particles of organic material to isolate them from the gelatin and the silver bromide. When development takes place the oxidation products dissolve in the organic material and react with the couplers. In this case the film is developed as a negative in complementary colours and prints are made on paper base coated with a similar type of emulsion. In the Agfacolor, Kodachrome, and Kodacolor processes the final coloured images contain no silver.

In the Technicolor process, three separate negatives are produced in a special camera. Three positive prints are made in relief in hardened gelatin and these hardened gelatin films are used as printing matrices by means of which successive dye images may be impressed upon the final print.

For the making of prints in colour on paper the methods at present available to the amateur would appear to be:—

(*a*) Three-colour Carbro;
(*b*) Duxochrome;
(*c*) Eastman Wash-off Relief;
(*d*) Chromatone.

The first of these is an extension of the ordinary Carbro process and in it bromide prints are first made from the separation negatives. These are placed in contact with bichromated gelatin tissues of the appropriate colours. Where the tissue is in contact with the silver image the gelatin is insolubilized and thus dye images are produced in hardened gelatin. The unhardened gelatin is dissolved away in a warm water bath, the images being supported during this "development" process on specially waxed celluloids. These images are superimposed in register on a temporary paper support and then the composite is transferred to the permanent base. This is the process in broad outline, but it must be emphasized that for successful results it is necessary to standardize the technique absolutely and to work under carefully controlled conditions of humidity and temperature. Vivex prints produced by a process which generally resembles Three-colour Carbro are among the most beautiful which have ever been prepared by direct photographic methods.

The **Duxochrome** process resembles in some respects both Carbro and Wash-off Relief. From the separation negatives prints are made on Duxochrome films which are coloured magenta, blue-green, and yellow and which also contain silver salts. Relief images are produced and the unhardened gelatin dissolved away in warm water. Then the silver is bleached out with ferricyanide hypo and finally the three images are transferred to a single paper base.

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* This process must not be confused with the old Kodacolor process which embodied a lenticular film.

Eastman Wash-off Relief is representative of the Imbibition processes. This method, like Technicolor, involves the preparation of three matrices of hardened gelatin from which dyes are transferred to the final paper support which contains a mordant to prevent bleeding.

Chromatone is an example of a chemical toning method which is reasonably simple and which gives excellent results. Materials for the process are marketed by the Defender Company, the formulæ and methods being due to F. H. Snyder and H. W. Rimbach of New York. From the separation negatives positives are made on special stripping paper. The silver deposits are now bleached and toned yellow, magenta, and blue-green respectively and then superimposed on a paper base.

THE MAKING OF SEPARATION NEGATIVES

To produce a colour print by any of the methods outlined above and, indeed, by any of the photo-mechanical printing processes so far introduced, it is necessary first of all to make separation negatives, *i.e.*, a series of ordinary black and white negatives each taken through one of the analysis filters. These negatives, as we have seen, each tell part of the story and positive images made from them in appropriate colours when superimposed constitute the coloured reproduction. When the original is a static subject it is a simple matter to make the necessary exposures one after the other, changing the filter each time, but when the subject is in motion the case is otherwise. Here there are two possibilities: one may use a "one shot" camera, in which by means of reflecting systems, three separate images identical in size and representing the red, green, and blue aspects of the subject are obtained on three different plates at one and the same time, or one may produce a full colour transparency (which can be done by several systems with one exposure in an ordinary camera) and from this, intermediate separation negatives may be made at a later time. For portrait work and subjects nearly at rest, the separation negatives can conveniently be made by means of a camera fitted with a "repeating back," with which device the separate exposures can be made on adjacent areas of one long plate (or on three separate plates placed side by side in the slide) with very great rapidity.

Sets of separation negatives must be correctly balanced both as regards exposure and development. It is necessary to know the filter factors for each of the analysis filters for the particular sensitive emulsion and type of illuminant—it is possible to obtain balanced filters which with certain specified lighting conditions and with a given emulsion require equal exposures. It is necessary also to develop all three negatives to the same contrast and except with a few special emulsions this involves the giving of different development times to the different negatives. It is usual to place a neutral stepwedge as a subsidiary subject so that it appears in the camera

field and on the negatives just outside the boundary of the image of the original subject, and this device makes it possible not only to tell if the negatives are correctly balanced, but also to judge the colour balance of the final print. Again, even when the separation negatives are made direct, *i.e.*, in the camera from the original subject, it is common practice to make a colour transparency to act as a guide for the actual making of the print.

THE FOURTH OR GREY PRINTER

In photo-mechanical printing it is often impossible to produce a satisfactory print, even from three correctly made separation negatives. Balance is difficult to maintain and particularly in offset lithographic printing the inks in use are not sufficiently intense to give good blacks by superposition. These difficulties are met to some extent by the employment of a fourth or grey impression, the corresponding negative usually being made through a green filter.

CORRECTING THE SEPARATION NEGATIVES

It is common knowledge that a considerable amount of retouching has to be done to the separation negatives or to intermediate positives if good colour balance is to be achieved. This retouching is frequently done by trial and error, control being effected by means of stump or pencil applied to the back surface of the negatives. There are, however, certain semi-automatic methods of effecting some correction which have recently received attention. Consider one aspect of the problem.

The negative made through the green filter is the magenta printer, *i.e.*, it is the negative record of the distribution of magenta in the original and all the silver image which it bears should be derived from the not-magenta parts of the original, *i.e.*, from the green and neutral areas.* Suppose that the green filter transmits some red light—as it always does. Under these circumstances the negative made through it will bear silver image derived from the red light transmitted by the filter and there will be two images superimposed, one produced by light from the not-magenta areas of the original

* The particular application of the masking method to the correction of faults produced by the taking filters is of importance in additive colour synthesis and the case is a little more complicated than might appear from the description given. In fact each separation filter should have a greater or lesser *negative* transmission in the regions of the spectrum transmitted by the other two filters, and each separation negative, whilst bearing silver image derived from the parts of the subject reflecting light of the colour transmitted by the corresponding filter, must also bear low contrast positive images corresponding to the distribution of colour complementary to that transmitted by the filter. It will be clear that these further requirements can still be met, at least approximately, by the use of properly made masking positives of contrast such that they do more than effect the exact cancellation of the negative images which in the simple description above have been called "secondary." In subtractive synthesis, and it is here that the masking method is of greatest importance, the correcting masks are introduced to compensate for the failings of the printing colours.

and one by light from the not-blue-green areas. It will be clear that this "secondary image" can be cancelled out by adding the right amounts of silver over all the rest of the negative, and this is conveniently done by binding up with the negative the positive counterpart of the image produced by light coming from the not-blue-green areas, *i.e.*, a positive made from the negative taken through the red filter.

This principle was first described in 1897 by Albert, who patented methods of correcting colour separation negatives by means of masking images bound in register with the negatives themselves. It is clear that such methods certainly point the way to very important advances in colour reproduction.

MATERIALS

It will be clear that in colour work where it is necessary to produce part images as separate entities and then to recombine them in register to produce a final coloured composite, it is essential that the part images shall retain exactly their original dimensions. For this reason plates have a marked advantage over films and are normally recommended for all work of this kind. The type of plate to be used will depend very largely on the work to be undertaken, but for the making of separation negatives of static subjects the usual choice is Ilford Special Rapid Panchromatic. For work with repeating back or one-shot cameras a faster plate, such as the Hypersensitive Panchromatic or H.P.3, is preferred.

CHAPTER XXIII

PHOTOMICROGRAPHY

DEFINITION

The term photomicrography is usually held to denote photography with or through the microscope. In the broadest sense it must be applied to many true photomicrographs of macroscopic detail which are taken without any microscope at all. These are low-power magnifications mainly concerned with the surface detail of opaque objects and to this type of work the term photomacrography is applied. Photomicrography may, therefore, be defined as the recording by photographic means of magnified images of minute objects.

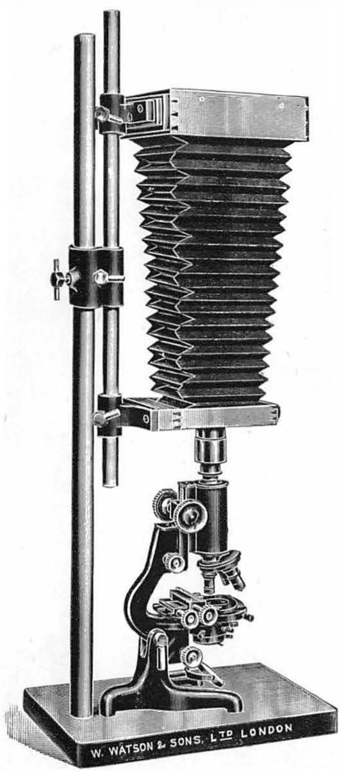


Fig. 108. Watson's vertical photomicrographic camera.

PHOTOMACROGRAPHY

As described above, this term specifically relates to the recording of detail visible to the naked eye, requiring magnification to become of real value as a photographic record, yet not involving the use of a lens system other than that of the camera.

Apparatus

The method requires the use of a vertical camera, the baseboard and photographic plate being horizontal, while the optical axis remains vertical throughout. The apparatus illustrated in Fig. 108 shows a commercial stand consisting of a substantial base supporting a rigid pillar holding the camera. The camera is capable of ample extension and is easily adjustable both as regards this and also to any position on the pillar support. For use without a microscope the front panel must be fitted with a focussing mount taking flange adapters for lenses. A suitable stand of home construction to which a half-plate camera can be attached is illustrated in Fig. 109. The camera should be of the front focussing type having double extension taper bellows. The

vertical board measures 36 in., and has a central slot (grooved at the back) through which the camera screw engages the base of the camera. A square metal plate sliding freely in the groove will prevent the screw from bruising the wood, and a yard measure pinned down the length of the groove will provide a convenient means for recording magnification, etc.

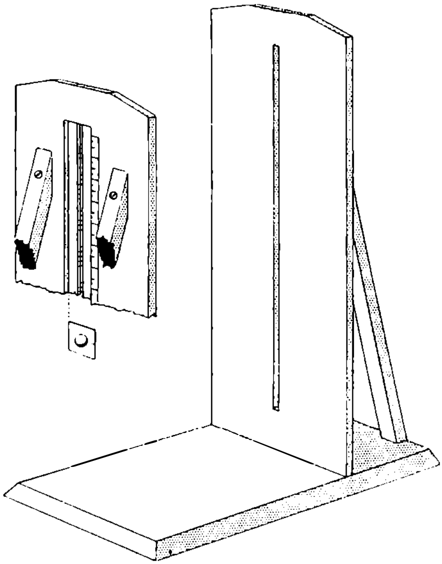


Fig. 109. Vertical stand for home construction.

Magnification

The means of obtaining magnification closely resemble those for enlarging from negatives. The lenses used must be good quality anastigmats fitted with iris diaphragm $f/4{\cdot}5$ and of short focal length ranging from 20 mm. to 10 cm., those of the micro-planar type and similar commercial types being particularly suitable.

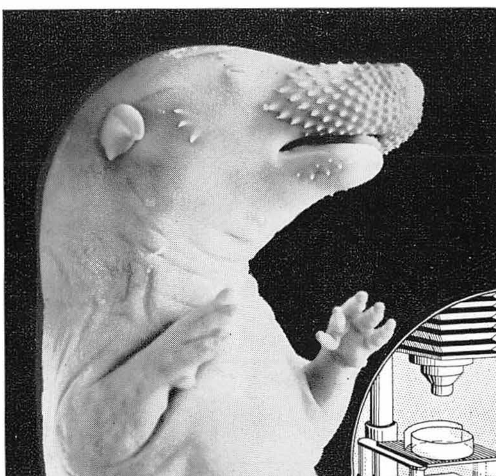
Procedure

The camera extension controls the magnification and it is advisable to prepare a table of magnifications which are obtained with each lens at varying camera extension. To do this the camera should be fully extended and adjusted on the pillar or vertical board so that the lens is at approximately its focal length above the baseboard. Place a graduated rule—millimetre scale for preference—on the board and illuminate it by means of a table lamp. With the lens at open aperture the image should be visible on the camera screen and without alteration of extension the whole camera can be raised or lowered until the image is sharply focussed. The magnified

image of the rule can be measured by a rule of similar type and the amount of enlargement calibrated and the position of camera on stand and the extension should be carefully recorded. The same procedure should be carried out using less extension until one has determined all intermediate magnifications which may be useful with the one particular lens; other lenses will be similarly dealt with and tabulated for future use.

Types of Specimen

It is frequently necessary to photograph specimens in fluid, this applies particularly to medical and natural-history specimens which would be seriously damaged if allowed to become dry. These specimens are very difficult to arrange, but they can be supported by small strips of glass and propped into position in a variety of ways; very small specimens may conveniently be placed in a hollow



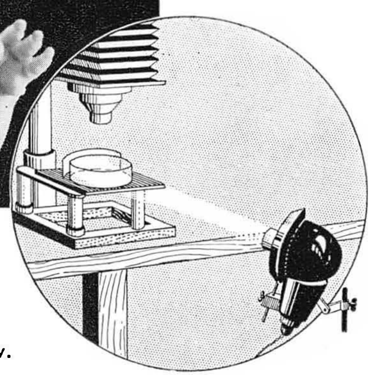


Fig. 110.
Head of embryo water shrew.

formed in a piece of ebonite. Geological specimens and fossil forms are more easily arranged with the aid of some Plasticine; botanical specimens and insects do not present any great difficulty.

Illumination

The illumination is of primary importance and must be very carefully arranged to avoid hard shadow effects. Always remember that

within a very minute area the lighting has to show up to the best advantage every scrap of visible detail and probably much more that passes unnoticed by normal vision. Diffuse daylight is very useful, but owing to variability it is preferable to adopt some form of artificial lighting which will be both constant and capable of control. Probably most useful for general purposes is a 60-watt opal bulb in metal reflector mounted on an adjustable table lamp-stand. This may be used in conjunction with a bull's-eye condenser when necessary to concentrate the beam, although particular cases call for special devices. Fig. 110 indicates the means adopted for displaying the surface detail of a specimen; the concentrated beam from a lamp passing upward obliquely through the bottom of a glass dish. A small piece of blotting paper at the back of the dish acts as a reflector to relieve the back shadow. Compare this photograph with Fig. 111, which is an example of normal straight illumination from the 60-watt opal lamp mentioned.

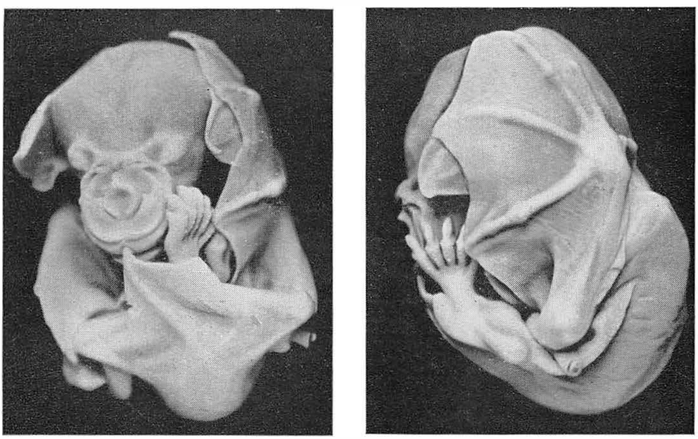


Fig. 111. Typical photomacrographs. Embryo bat.

General Technique

Set specimen as desired to display most important detail; arrange lighting to best advantage; set camera, extended, with lens at the approximate distance of its focal length above specimen and iris open. Focus image on screen and gently rotate specimen to be certain that the illumination is really the best possible; then close iris gradually, observing increase of sharpness until desired position is reached. After some practice this becomes more easy, although the screen image is usually somewhat dim and a focussing cloth is necessary to get the best results. If no shutter is provided on the

camera the exposure can be controlled by using a sheet of card in the path of light.

Transparent specimens can be photographed if raised above the baseboard on a sheet of glass, elevated sufficiently to introduce either an illuminant or preferably by using the light reflected from the surface of a piece of white card or blotting paper placed beneath the specimen at an angle of 45°.

Choice of Sensitive Material

For specimens of neutral colour photographed by reflected light the Ilford Ordinary plate is very useful, but where there is any tint of yellow due to the use of preserving fluids an orthochromatic plate is recommended. Coloured specimens, and particularly those showing definite colour variations, necessitate the use of panchromatic material, and on occasion the introduction of a suitable colour filter will be necessary. This may be interposed between the light source and the specimen or, alternatively, a small circular filter can be inserted inside the camera and placed on the back of the lens without interfering with the sharpness of the image. The panchromatic plates recommended for this work are the Ilford Rapid Process Panchromatic or, where softer results are desirable, the Ilford Soft Gradation Panchromatic plate. All plates used for photomacrography should be backed.

Where it is desired to use flat film, Ilford Fine Grain Ordinary will be found to constitute a convenient non-colour sensitive material, or, if greater contrast is required, Ilford Diapositive film will prove suitable. In the panchromatic class Micro-Neg film will be found to give excellent results. All but the first of these are available also in the 35 mm. size.

Exposure times will vary in accordance with individual apparatus, and it is not practicable to give definite information, although it may be said that while an Ordinary plate might require an exposure of some minutes' duration, the exposure when using panchromatic material would be considerably less.

Fig. 111 may be taken as a typical example of photomacrography at a magnification of × 15 diameter, using a 35 mm. micro-planar lens with camera extension of 50 cm. and illuminated by a 60-watt opal lamp in reflector shade. Plate, Ilford Process Panchromatic; exposure, 1½ min.; developed in Ilford ID–1 (Pyro-soda).

PHOTOMICROGRAPHY—WITH THE MICROSCOPE

Photomicrography is popularly understood to imply the photography of magnified images obtained by the use of the microscope used in conjunction with the camera.

Apparatus

It is possible to dispense with the camera provided that the illuminant can be enclosed in a light-tight box and the work done

in a darkroom. Fig. 112 shows a very simple apparatus which is capable of giving good results, even at relatively high magnifications. The cubical box houses the illuminant—a 100 c.p. "Pointolite" lamp—the light from which passes through a brass tube on the top of the box into the sub-stage condenser. No stray light gets into the room except that which results from the luminosity of the top lens of the condenser, and this is insufficient to fog, during development in the same room, the plates most commonly employed in the work. A right-angled prism is fitted on the eyepiece and throws the image on to the easel; the latter is movable to and from the microscope, and carries a ledge movable up and

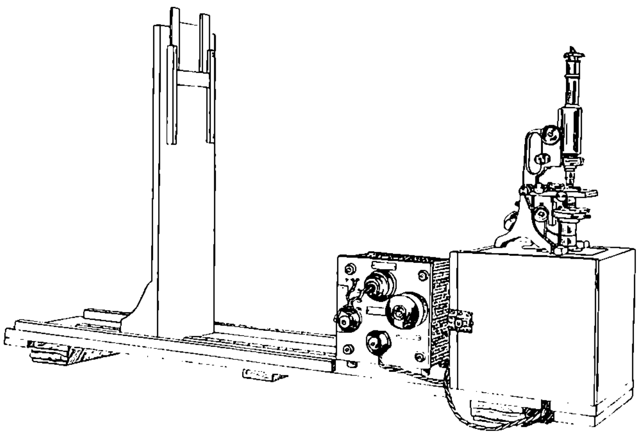


Fig. 112. Microscope without camera.

down, on which the photographic plate may be placed. Focussing is done on a white glass (a photographic plate will do), the image being viewed by reflection. When this has been done a card may be interposed between eyepiece and plate, a sensitive plate substituted for the focussing screen, and the exposure made by withdrawing the card for the required time.

The best equipment supplied for photomicrography comprises a camera of long extension; a microscope, preferably having a large barrel or body tube, and provided with the essential outfit of objectives, oculars and sub-stage condensers; an illuminant on adjustable stand with one or more condensers which function as light collectors. All of these pieces are assembled on a rigid optical bench along which the components can be moved in accurate alignment.

Although there are many different forms which the entire apparatus may take, the commonest and probably most useful type is that in which the optical axis is horizontal throughout, the

microscope stage and the photographic plate being vertical. At least one form of optical bench is on the market in which the microscope and camera axes can be varied from the horizontal to the vertical at will.

Practical Considerations

Choice of Illuminant. The light source for photomicrography should be constant in intensity; the intensity should, as far as possible, be uniform all over its surface, and it should be as small as possible. No better illuminant exists than the "Pointolite" lamp for direct current, which very closely approaches the ideal requirements. The 100 c.p. variety is suitable for all photomicrographic purposes. The source of light consists of a small Tungsten ball which is rendered white hot by electron bombardment from a Tungsten wire placed opposite. Part of this wire constitutes a filament. To light the lamp, current is made to pass through the filament. When this becomes hot an arc discharge between the wire and the ball is produced automatically and the ball moves over to a harder part of the wire. The current through the filament must then be switched off and the lamp is ready for use.

Of equal value where the mains supply is A.C. is the 6-volt 108-watt ribbon filament lamp used in conjunction with a transformer of appropriate size. The filament of this lamp takes the form of a narrow band of Tungsten arranged horizontally across two rigid supports. A considerable amount of work is also done by means of small filament lamps of the motor headlamp type. Suitable lamps of this type are supplied by optical instrument manufacturers.

Other illuminants available include small arc lamps with some of which a clockwork mechanism is available, and mercury vapour lamps.

The arc lamp is generally unsteady and for all but the highest magnifications is too intense, while the heat of the projected beam has an injurious effect on mounted specimens which renders its use undesirable. The ordinary electric light bulb is not suitable for photomicrography, although the opal bulb type can occasionally be used for very low-power work. Mercury vapour lamps are generally used only when monochromatic light is necessary for special purposes, and then only in conjunction with special filters.

Adjustment of the Microscope

It is beyond the scope of this chapter to give instruction for the optical adjustment of the microscope; information on this subject will be found in text-books on microscopy. (*Microscopy*, by E. J. Spitta, etc.)

General Principles of Apparatus

Although a preference for an ideal equipment has been stated, it must not be taken to indicate that work of quite excellent quality cannot be done with less pretentious apparatus. Absolute rigidity

is essential in the complete assembly and vibration should be avoided as far as possible. Accurate centring through the entire optical system from light source to light collecting condensers, through the microscope to the camera screen is essential to success; inaccuracy in this respect will lead to many troubles such as poor definition, impaired resolution, and lack of uniformity over the whole field.

The adoption of small illuminants and the provision of light collecting condensers on the optical bench are regular features of photomicrographic practice. The small size of the light source ensures a maximum concentration of light, which the collecting condenser will project on to the sub-stage condenser of the microscope enlarged to the size necessary to fill the aperture of the objective with light.

The light collecting condensers function (*a*) for low-power work, projecting a parallel beam which fills the field of the simple sub-stage condenser of the microscope used for this purpose, and (*b*) for medium and high powers, projecting a convergent beam focussing an image of the light source on the sub-stage iris diaphragm which functions in front of the Abbe condenser normally used for these higher powers. If the top component of the Abbe condenser is removed by unscrewing, the lower portion forms an admirable simple condenser suitable for photomicrography with low-power objectives. When used in this way the sub-stage iris must be wide open.

PHOTOMICROGRAPHY WITH MINIATURE CAMERAS

Miniature cameras taking 35 mm. film can be used for photomicrography. With types from which the lens cannot be removed, the camera is set to infinity focus with iris at open aperture and the camera lens closely applied to the eyepiece of the microscope. The camera lens takes no essential part in image formation, and miniature cameras from which the lens can be completely removed are considerably more suitable.

The provision of some form of focussing device is necessary, and the Leitz and Zeiss outfits include special attachments incorporating reflex focussing eyepieces. Extension tubes of various lengths (up to about six inches), threaded to screw into the lens flange, ensure that the whole film frame can be filled; the inner surface of the tubes must be blackened with non-reflecting paint.

Ilford Micro-Neg film (Panchromatic) is recommended; exposure time should be generous and a fine-grain developer of the Metol-hydroquinone-borax type (Ilford ID–11) should be used. A suitable non-colour sensitive material is Ilford Diapositive film.

It is suggested that the microscope can be used as an enlarger for miniature film negatives, the negative being placed on the stage of the microscope and projected by an objective of low power, such as the 10 cm. micro-planar lens, on to bromide paper.

Types of Subject

It is safe to assume that by far the greater number of photomicrographic subjects concern thin sections of plant or animal tissue which have been selectively stained and mounted on a glass slide, covered with a thin cover glass cemented with canada balsam. These specimens are photographed as transparent objects by transmitted light, *i.e.*, the light passing through the specimen. Dried specimens are occasionally mounted between two glass slides without mountant and may be photographed as transparent objects.

Opaque objects can be photographed with the microscope objectives, but this must be done by reflected light, the lamp being placed in front of the microscope stage and the light concentrated by a condenser on to the surface of the specimen. This particular branch of photomicrography is best carried out with the microscope and camera in the vertical position. Fluid specimens are also more easily photographed on the microscope with vertical camera, although the illumination must be transmitted by reflection from the mirror of the instrument as used for visual observation.

Magnification

The combination of objective and ocular in association with camera extension determine the magnification and to measure magnification a stage micrometer is used. This consists of a microscope slide on which is mounted a finely graduated scale, usually 1 mm., divided into tenths and hundredths. The scale is placed on the stage of the microscope and the image sharply focussed on the camera screen; the magnification is computed by measuring the enlarged image of the micrometer scale against a millimetre rule, remembering that the scale projected is of fractions of one millimetre.

Technical Considerations

It should be noted that very low-power photomicrographs of stained sections are taken with the short focus anastigmatic lenses used for photomacrography. These lenses do not work with oculars in the microscope, and on account of the wide field which they cover it is necessary to remove completely the eyepiece tube from the microscope and to provide a suitable form of microscope-to-camera connection. The lens must be used at open aperture and a simple condenser (or lower half of Abbe condenser) used in the sub-stage; the sub-stage iris must also be open wide.

Choice of Sensitive Material

Consideration of the type of specimen will be necessary before a decision can be made as to the most suitable medium to use. An unstained section or entire mount will rarely require panchromatic material, and can usually be recorded best on an Ilford Ordinary plate, while such objects as insects, etc., mounted whole will be of yellow or brownish colour, calling for the use of panchromatic material in conjunction with a colour filter chosen with regard to the result desired. Thus a dried specimen without colour, such as a fish scale, can be mounted between two pieces of glass and will form a quite reasonable preparation from which a low-power photomicrograph may be made. Fig. 113, scale of a salmon,

Fig. 113. Typical photomicrograph. Scale of salmon.

illustrates this subject, semi-transparent and lacking colour, photographed at a magnification of × 9 diameter, using a 50 mm. micro-planar lens on microscope with camera extension 50 cm. The illuminant, a 6-volt 108-watt ribbon filament lamp on the horizontally arranged optical bench already described being used. The screen image was of great brilliance and had to be reduced in intensity by placing a green colour filter (Micro 3) plus a neutral density filter between the light source and the microscope, in order to allow an exposure time which did not require to be fractional of a second. It may be noted that speeded shutters are rarely applied to photomicrographic outfits, in fact, the exposure is frequently

controlled by the use of a piece of card inserted in the light ray near the sub-stage of the microscope.

Using an Ilford Ordinary plate (backed) the exposure time was 20 seconds only, followed by development for five minutes at 65°F. (18°C.) in ID–1 Pyro-soda.

By way of comparison, Fig. 114 shows a different treatment for unstained specimens of moderate size mounted entire. The specimen of Bladderwort unstained, but cleared and mounted entire in suitable medium under glass, was dull and uninteresting viewed by transmitted light, but became a glistening white object if subjected to oblique illumination. This was accomplished by removing the

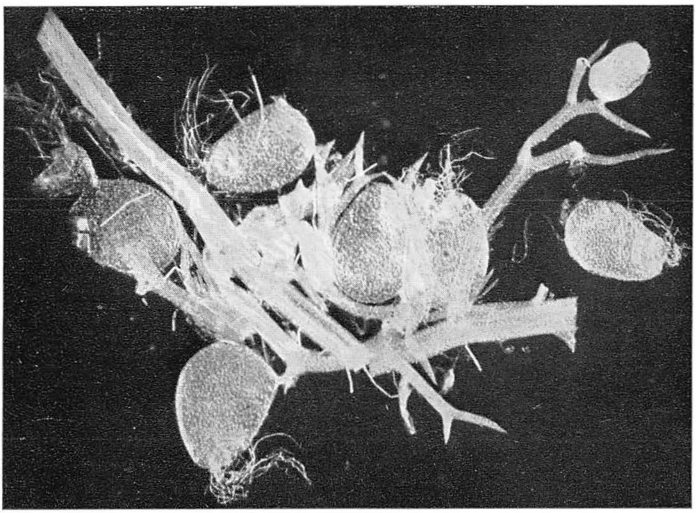


Fig. 114. Typical dark ground illumination photomicrograph. Bladderwort.

sub-stage condenser fittings from the microscope and concentrating the light from a 60-watt opal lamp through a bull's-eye condenser to pass obliquely—angle of 30 degrees approximately—through the slide from behind.

The conditions were: Lens, 50 mm. micro-planar; extension, 50 cm.; Ilford Ordinary plate—exposure 45 seconds; development time, 3 min. ID–1 at 65°F. (18°C.).

The usual procedure for obtaining low-power dark ground photomicrographs is to place an opaque disc or wheel stop in the sub-stage condenser of the microscope, adjusting the position of the condenser until the image of the opaque disc fills the aperture of the micro-objective and the specimen is observed glistening against a dark ground. High-power dark ground results are not so easily

obtained and a specially prepared dark-ground condenser for high power is recommended.

Many photomicrographers employ panchromatic materials exclusively for their work, since their use places a vast amount of control in the hands of the operator. In fact, for the great majority of photomicrographs of stained preparations the Ilford Rapid process Panchromatic plate will satisfy all requirements and it is certainly a great advantage to limit the number of types of sensitive material in use in order to obtain uniform results. Exceptional subjects may require the use of a less contrasty medium and the Ilford Soft Gradation Panchromatic plate will be found of use in this direction.

Most dye-stained preparations are differentially stained by the use of (*a*) a primary staining of the nuclei, and (*b*) a contrasting colour or counterstain for the remaining tissues. Fig. 115, Ciliated

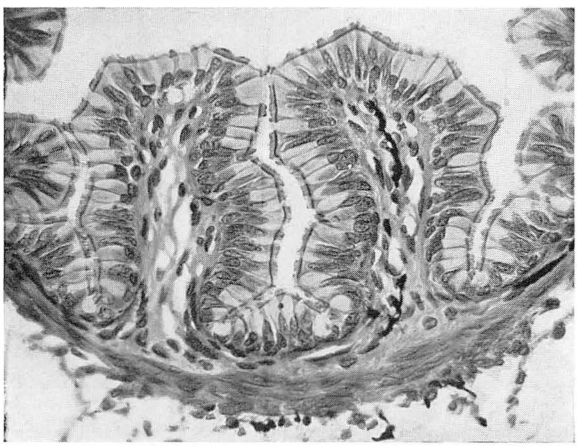


Fig. 115. Ciliated epithelium-œsophagus of salamander.
A typical example of photomicrography by transmitted light.

epithelium-œsophagus of salamander—is a good example of this type of stain and counterstain where the nuclei were stained with carmine (red) and the remaining structures counterstained with anilin-blue. The conditions for photographing it were: Objective, 8 mm.; ocular, × 10; extension, 70 cm.; illumination, 100 c.p. "Pointolite" lamp; plate, Ilford Rapid Process Panchromatic; colour filter, Micro 3 (Green); exposure, 4 seconds; developer, ID-1, 1½ minutes. Many microscopical sections are stained with triple stains, making brilliant preparations and giving fuller differentiation to the structures. Unfortunately, the dye technique

cannot prevent the combination of colour in some of the tissues, thereby producing an intermediate coloration. Photomicrographs of these subjects must be made with the use of a colour filter which will display the structures of immediate importance to the greatest advantage, and it will rarely be found that other structures suffer by suppression, although the colour contrasts are changed.

Figs. 116, *a*, *b*, and *c*, are photomicrographs of a section stained with a triple stain which have been prepared to show how the use of appropriate colour filters will give considerable control over the results obtained. The coloration of the original specimen has been indicated (*a*), and similar optical conditions were used throughout, with the exception of change of filter.

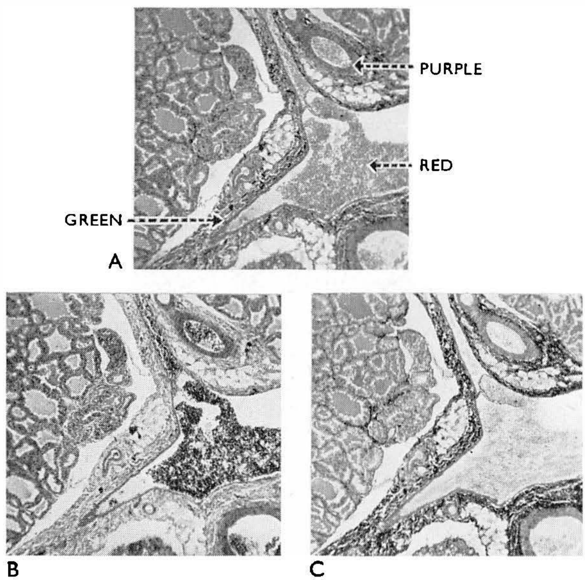


Fig. 116. Typical photomicrographs.

Subject: Veins in association with thyroid gland; stained Mallory's triple stain. Objective, 16 mm.; ocular, none used; extension, 55 cm.; magnification, × 55 diam.; plates, Ilford Rapid Process Panchromatic. Colour filters, Neutral density combined with:—

(*a*) Micro 9 (pale yellow); exposure, 2 seconds.
(*b*) Micros 2 + 3 (blue-green); exposure, 90 seconds.
(*c*) Tricolour red; exposure, 5 seconds.

All the plates were developed for two minutes at 65°F. (18°C.).

From these results it will be observed that (*a*) presents the appearance of uniform stain values without emphasis; (*b*) shows the red stained part of the section to greater advantage, while (*c*) reduces the red stained elements to pale shadows and gives emphasis to the green stain. Control in other directions is possible by careful selection of the colour filter—the use of a green filter (Micro 3) usually increases contrast, while the use of a yellow filter, such as Micro 4, will give reduced contrast, particularly when photographing insects of a brown colour which have been rendered transparent before mounting.

PHOTOMICROGRAPHY WITH INFRA-RED PLATES AND FILMS

The introduction of plates and films sensitive to the near infra-red part of the spectrum has placed a useful tool in the hands of the microscopist. It is not possible to give any rule for determining whether the infra-red plate will offer any advantage over ordinary or panchromatic materials with any particular object; everything depends on the spectral-absorption characteristics of the subject, and a trial must be made to determine the question. Generally speaking, the subject must possess a fair degree of transparency to the infra-red rays to which the plate is sensitive, and this can be determined only by trial. The greatest advantage is obtained with the infra-red plate in the photomicrography of subjects—such, for example, as certain insects—which show a greater transparency to infra-red light than to any of the visible rays. With such subjects an ordinary plate gives excessive contrast and no detail; often a panchromatic plate gives an improvement when used with a suitable filter; but the infra-red plate gives the best result owing to the softening of contrast which always attends the use of those rays to which the subject being photographed is most transparent.

FOCUSSING WITH INFRA-RED

The infra-red plate possesses the blue sensitivity of an ordinary plate in addition to the infra-red sensitivity, and the former considerably outweighs the latter. Hence the use of this plate without an infra-red filter—that is, a filter transparent to infra-red rays but opaque to visible light—is useless. This filter may be used in the same position as any other filter in photomicrographic work, but it is recommended that it be placed over the aperture in the light-source housing. Owing to the fact that most microscopic objectives and eyepieces are not corrected for infra-red light, it will be found that there is a difference between visual and infra-red focus. Obviously, it is not possible to focus through the infra-red filter, as it is opaque to visible light. With some lenses it is sufficient to focus through a *red* filter, *e.g*., Ilford Tricolour Red, and to neglect any further error; but it will generally be found that, although focussing

through a red filter assists considerably in the attainment of the best definition, a further allowance has afterwards to be made on the fine adjustment, and the extent of this allowance has to be determined by experiment. The procedure recommended, therefore, is to focus with the Tricolour Red filter, then to replace this by the infra-red filter, and make any further fine adjustment as experience may have shown to be necessary. In general this further adjustment will be in the direction of moving the objective a little *away* from the slide.

EXPOSURE AND DEVELOPMENT

Accurate estimate of exposure is probably more difficult in photomicrography than in most branches of photography in as much as the number of variable factors is greater. While the light source may be regarded as fairly constant, the density of the subject, the magnification and the working aperture are factors whose combined effect is not readily estimated. If, however, a careful record of all conditions employed when working is made the difficulties will become less as practical experience is gained. From such a record it should be easy to repeat conditions with a well-appointed apparatus. It will be recognized that the use of one particular plate for all purposes has much to recommend it in this connection—hence the great advantage of a panchromatic material with which all subject requirements can be met. When using the Ilford Rapid Process Panchromatic plate the duration of exposure should be sufficient to produce a negative of good quality at a development time not exceeding two minutes at 65°F. The Pyro-soda developer (Ilford ID–1) is frequently used for photomicrographs with all the plates normally employed for this work, and many workers maintain that it has particular advantages over all other formulæ. In fact, excellent results can be obtained with all well-balanced developers, and the conclusion to be derived is simply that the best results are obtained by the use of a formula with which one is thoroughly accustomed. Control in development may be used with success by experienced workers, but once again the best advice to the beginner is to standardize time, temperature, and formula. Negatives should be printed on Ilford Glossy Bromide paper, Normal grade, unless a more vigorous print is desired, when a more contrasty grade of paper may be used.

USE OF COLOUR FILTERS

As we have seen, the correct use of colour filters is of the greatest importance in panchromatic photomicrography. In order to provide for the needs of the microscopist, nine "Micro" filters have been produced specially for this work. They may be obtained in the usual optically worked glass mountings, but these are not essential and, in fact, they are often inconvenient. Provided the filter is *not* placed between the subject and its image, first-class

optical quality is not necessary. This condition may be satisfied by placing the filter, cemented in very thin glass, between the light-source and the object; a small cell is fitted in most sub-stage condenser mountings for this purpose, two standard sizes of filter being recognized, *viz.*, 22 mm. and 34 mm. diameter. Ilford Micro filters (sub-stage pattern) are normally supplied in these sizes. Ilford Neutral filters are supplied for use in conjunction with them.

FILTERS FOR CONTROLLING COLOUR CONTRASTS

In photomicrography it is usually necessary to render the fullest possible detail in those parts of the image which are of *one* colour, and to throw up the other colour in sharp contrast. The rules to be remembered in selecting a filter for detail or for contrast are quite simple. For *detail*, use a filter of as nearly as possible the same colour as the object to be photographed—or that part of the object in which the detail is required; for *contrast* use a filter of a colour as nearly as possible complementary to the colour of the object in which contrast is needed (*i.e.*, a filter which absorbs those rays of the spectrum which preponderate in the light reflected from, or transmitted by, the object). The following table is a rough guide to the selection of a *contrast* filter:—

When the object is:	The filter to use is:
Red	Blue-green
Orange	Violet
Yellow	Blue
Pink	Deep Green
Purple	Light Green
Blue-green	Red
Green	Pink
Blue	Yellow
Deep Blue or Violet	Orange

In the case of differentially stained preparations it rarely occurs that the two stains are quite complementary in colour; hence no single filter can be ideal both for contrast in one colour and at the same time for detail in the other. As a rule the filter should be selected for maximum detail where detail is required, and the other colour will usually be sufficiently nearly complementary to the first to give a contrasty image.

FILTERS FOR CONTROL OF GENERAL CONTRAST

In taking photomicrographs of particularly difficult subjects, considerable trouble is often experienced in obtaining satisfactory gradation. The Special Rapid Panchromatic plate may give too soft a result, while the Rapid Process Panchromatic plate may be too contrasty. In such cases as this much can be done by judicious control of development, but there is much to be said in favour of

adhering to standard practice in this matter. There is, however, one property of the panchromatic plate of which use can be made here, namely, the variation in contrast of the image according to the mean wavelength of the light used. By using a fairly deep yellow filter (Micro 4 or Micro 5) a very considerable increase in general contrast of the image will result, while the softest results are obtained by the use of a deep blue-violet filter, such as Micro 1. This effect is most particularly of value with very transparent, faintly-coloured objects; with strongly coloured objects the rule for contrast-filter selection, already given, may interfere.

FILTERS FOR IMPROVED DEFINITION

Like most optical systems, the optical system of a microscope is subject to a certain amount of chromatic aberration. It is very difficult, if not impossible, to produce objectives and eyepieces which are corrected for all wavelengths, and most of them are, therefore, corrected for rays in the neighbourhood of the maximum sensitivity of the observer's eye, *i.e.*, the yellow-green of the spectrum. Hence some imperfection may be expected if one takes a photomicrograph on an ordinary (blue-violet sensitive) plate with lenses which are yellow-corrected. In a very large number of subjects the error may be so small as to pass unnoticed, but in taking extremely minute objects at high magnifications, it may be serious. The remedy is two-fold; firstly, use a panchromatic plate and, secondly, use a filter which will transmit only a narrow band of the spectrum in that part for which the lenses are corrected. Such a filter is the Micro 3. Theoretically, the narrower the spectral band employed the better the definition. Narrower bands in the yellow-green than that of the Micro 3 can be obtained by superimposing two filters (*e.g.*, Micro 3+5); the increase of exposure necessitated, however, is very great, as will be seen from the table on page 424, and unless the apparatus is *very* rigid, small vibrations may have time to vitiate completely the gain in definition which might have resulted from the additional filter.

ATTAINMENT OF HIGH RESOLUTION

By the resolving power of a microscope is meant the magnitude of minutest detail which it will render visible. Resolving power has been discussed in Chapter I, and from what has been said it will be clear that it does not merely depend upon magnification. There is a limit to the resolving power of the best microscope, and one of the limiting factors is the wavelength of the light employed. Resolving power increases as the wavelength of the light decreases. Hence the maximum resolution is to be obtained by using blue or blue-violet light, such as is passed by the Micro 1 filter. Care may, however, be needed in avoiding the loss of definition resulting from the fact that the lenses are yellow-corrected.

For special purposes where the highest resolution is required, light of still shorter wavelength—ultra-violet light—is utilized in conjunction with specially corrected objectives of "fluorite," which is transparent to the ultra-violet. The exposure factor of a filter will depend on the source of light and the sensitive material used. For example, the use of a blue filter when used in light deficient in blue will necessitate a greater lengthening of exposure than when used in a bluer light. Thus its filter factor to half-watt light will be greater than to daylight. Again, a red filter will more greatly increase the exposure required when used with an emulsion not very sensitive to red light than when used with a more fully sensitised type. The following table refers to the use of Ilford Rapid Process Panchromatic plates.

Filter	Exposure Factor		Transmission Bands	Colour
	Daylight	Halfwatt or Pointolite		
Micro 1 ...	12	18	Blue end to 5000 Å ...	Blue-violet
,, 2 ...	7	10	4300–5500 Å ...	Blue
,, 3 ...	6–7	$4\frac{1}{2}$	4850–6000 Å ...	Green
,, 4 ...	3	$1\frac{1}{2}$	5050 Å to red end ...	Yellow
,, 5 ...	6	$2\frac{1}{2}$	5550 Å to red end ...	Orange
,, 6 ...	10	12	Blue end to 4800 Å and 6400 Å to red end	Purple
,, 7 ...	5	3	Blue end to 4900 Å and 5900 Å to red end	Pink
,, 8 ...	$1\frac{3}{4}$	$1\frac{1}{4}$	All but ultra-violet. Transmission increases, becoming complete at 4800 Å	Pale yellow
,, 9 ...	$1\frac{3}{4}$	$1\frac{1}{4}$	4600 Å to red end ...	Pale yellow
Micros 1 + 3	1000	1500	4800–5100 Å ...	Very dark blue-green
,, 2 + 3	25	18	4850–5500 Å ...	Green
,, 2 + 4	52	75	5050–5500 Å ...	Green
,, 2 + 6	70	100	4300–4800 Å ...	Violet
,, 3 + 4	10	7	5050–6000 Å ...	Yellow-green
,, 3 + 5	75	50	5500–6000 Å ...	Deep yellow
,, 5 + 6	150	100	6400 Å to red end ...	Red
,, 5 + 7	15	8	6000 Å to red end ...	Orange red

CHAPTER XXIV

CINEMATOGRAPHY

GENERAL

To-day the moving talking picture dominates the field of entertainment, its value as a medium for the dissemination of propaganda is already appreciated and to-morrow it will be accepted as the greatest weapon in the armoury of the educationist. Although it is just over 40 years since the first British audience paid for admission to the London Polytechnic to see Louis Lumière exhibit his cinematograph, there are now some 5,000 picture theatres in Great Britain alone, and it is estimated that in one normal year approximately 1,000,000,000 people pay for admission to these cinemas. In the same period 300,000,000 feet of 35 mm. positive film are manufactured, printed, and processed. Picture making on this scale is, of course, an enormous undertaking involving the work of thousands of people—in Hollywood alone it is estimated that 28,000 persons are employed—and photographic materials and chemicals are used in prodigious quantities.

Narrow width films and equipment are in considerable use by amateur cinematographers who find the making of ciné films a pursuit of absorbing interest. These so-called sub-standard films are also being used to an increasing extent in industry and for instructional work in schools and colleges.

The cinematograph film consists of a large number of "still" pictures photographed in rapid succession. When projected on the screen every picture is shown as a "still," the light being cut off by a shutter during the period in which the film is moved on the next frame. Owing to persistence of vision, a rate of projection of 16 pictures a second gives the impression of continuous motion. Flicker, however, is still noticeable at this periodicity and modern projectors, therefore, have shutters so constructed as to cut off the light 48 times a second. On a machine built for a projection rate of 16 frames a second, the light cut-off takes place once during the picture shift and twice while the picture is stationary. With the advent of sound on film the running speed of the film was increased to 24 frames per second, not for reasons connected with the illusion of continuous motion, but in order to provide a sufficiently long sound track to give reasonably good reproduction. For professional 35 mm. films, therefore, a taking and projection rate of 24 frames per second, which is equivalent to 18 in. of corresponding sound track was adopted internationally as a standard.

THE MOVING TALKING PICTURE

From pictures taken in rapid succession upon successive portions of a roll of 35 mm. perforated film a positive record is prepared. This film is also 35 mm. wide, perforated and near one edge it bears, between the perforations and the picture, the sound track just under 1/10th inch in width. This is printed photographically from a negative which is usually produced in a separate camera where, by means of an electrical link, the vibrations of the microphone are made to influence either the width of track illuminated by a beam of light or the intensity of the beam itself. The "married" positive, *i.e.*, the positive film bearing both picture and sound records, is made to pass through a projection lantern. This lantern has a sound gate as well as a picture gate, and whilst the light from a high-intensity arc is re-forming the original picture upon the screen a tiny beam of light is playing upon the sound track, suffering more or less absorption as it passes through in accordance with the original microphone vibrations, and finally falling upon a photo-electric cell. At this stage the fluctuations are translated back through electrical pulses into sound waves which reach the audience from loud-speakers situated behind the screen. The film passes through the picture gate in steps, but it must travel continuously through the sound gate; the sound record is printed nineteen frames ahead of the corresponding picture image so that corresponding parts will be passing through the two gates at the same moment.

FILM MAKING

The first step in the making of a film is the production of a scenario from which the "shooting" script is drawn up bearing full details of all scenes to be photographed. In film making story sequence is seldom followed. It is one of the special features of the cinema that the story may flash backwards and forwards in place and time and it would be uneconomic to make the cast and crews follow the story sequence, even if the "sets" were in adjacent studios. Therefore, all scenes connected with a particular set are photographed in succession, each being rehearsed almost *ad nauseam* before a camera is turned.

The camera equipment includes cranes and cradles from which angle shots may be obtained and tracking shots are made with the camera running upon rails. The film stock used is panchromatic negative of the highest speed consistent with fine grain. This is true both of outdoor and indoor work, but for newsreel camera work when pictures must be obtained in all weathers and lights, it is usual to have a still faster film, a somewhat coarser grain being permitted.

On the studio floor the lighting is either tungsten filament or arc, the latter being almost essential where colour work is being done. The lighting technique is decided upon with reference to subject and treatment by the camera man working in close contact with

his director. Sound and picture, except occasionally in newsreel work, are recorded on separate cameras running synchronously. Generally the two are recorded simultaneously, clappers being used to provide easily recognizable visual and audible records to enable the two records to be brought correctly together at the printing stage. In some cases, however, the sound is recorded separately. A record may be made of orchestral music and this record actually reproduced on the set during the shooting of the picture. Where

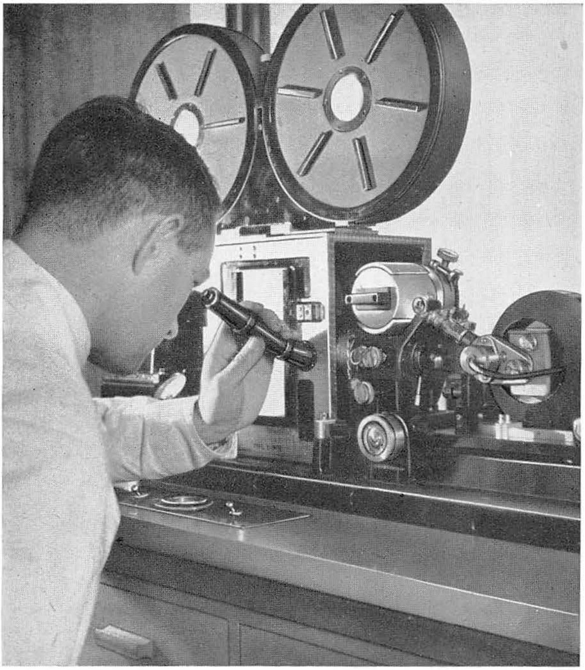


Fig. 117. SOUND CAMERA.
Photograph taken while sound recording was proceeding.
The operator is seen examining the track image on the film.

a song is being sung to an orchestral accompaniment the voice might be recorded first with a soft piano accompaniment to assist the vocalist with tempo and pitch. This method allows the director the greatest freedom, the camera man is not handicapped by the existence of innumerable microphones, and any required balance can be maintained between voice and accompaniment.

Two distinct methods of sound recording are in use, variable width and variable density, and the latter has two distinct variations.

In all three cases the amplitude or loudness is represented by the transmission of the portion of track passing the slit, but whereas in variable density there is a uniform density corresponding to each amplitude, in the variable width method the track consists of black image and clear celluloid, the transmission being governed by the ratio of clear to black. In these circumstances it is obvious that different types of developed image must be obtained to suit each of these systems.

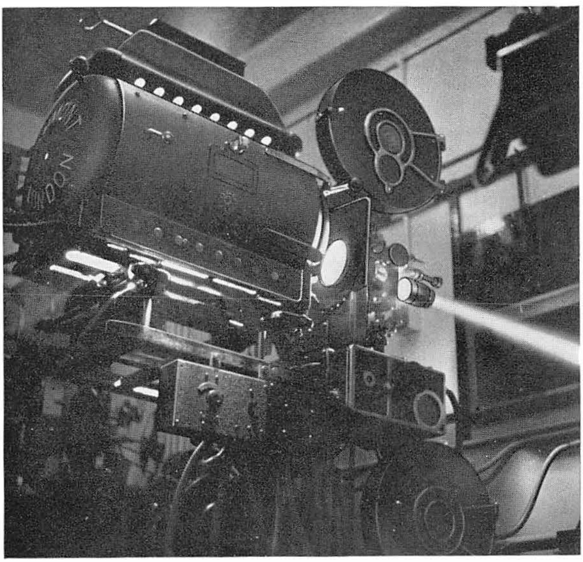


Fig. 118. 35 mm. PROJECTOR.

THE HANDLING OF FILM STOCK

The fire risk involved in the handling of cellulose nitrate is a very real one, especially as the material not only takes fire readily, but does so spontaneously if the temperature is raised above a certain point, which varies for different samples, but is generally in the vicinity of 190°C. The fire risk is the more dangerous because nitrate base contains all the elements necessary for combustion and no outside oxygen is required. Decomposition (without spontaneous combustion) takes place at temperatures above 100°C. and with increasing rapidity as the temperature is raised, the decomposition being accompanied by the loss of plasticizer, the film becoming more and more brittle. With increasing decomposition the material becomes brown and smells of nitrogen peroxide.

Non-flam base, *i.e.*, cellulose acetate the use of which is general as far as sub-standard films are concerned, has not been adopted for standard 35 mm. films, except in exceptional circumstances, because of its shorter projection life. Whereas nitrate base will allow of some 250–350 projections before the film is rendered useless, generally through scratches, acetate base under normal cinema conditions will only stand up to some 200 projections before breakage becomes so considerable as to render the film useless.

Cellulose acetate will not ignite spontaneously, nor will it burn unaided for more than a few seconds unless a strip hanging vertically is lit from the bottom. Even then the film generally breaks and smothers the flame. Exposure to high temperatures causes shrinkage with both nitrate base and acetate base, the effect being greater in the latter case.

So great is the fire risk involved in the handling of nitrate base that stringent legislation has been enacted to safeguard operatives and the general public alike.

For example, the amount of celluloid in a workroom at any one time must be kept as low as possible and must not exceed the supply immediately required for the work in hand. Celluloid waste must not be allowed to accumulate on the floor of the workroom, but should be collected either automatically as produced or at frequent intervals. Cinematograph film, except while necessarily exposed for manufacture, must be kept outside the workrooms in suitable receptacles provided with covers. No open lights or fires can be allowed in a room in which ciné film is being manufactured or handled, and smoking is prohibited. Adequate fire extinguishing apparatus must be available, together with facilities for escape.

The precautions which must be taken in the storage of raw stock to prevent deterioration of its photographic and mechanical qualities are simple. The films should be stored in well-ventilated vaults in the manufacturer's taped tins and care should be taken to avoid great variations in temperature and humidity. High humidity has a very bad effect on the photographic qualities of stock before exposure as well as on the latent image after exposure. On the other hand, films deprived of moisture become brittle and often show on development tree-shaped markings produced by "static" discharges. Fortunately, the nature of the material is such that it can be reconditioned by raising the relative humidity of the atmosphere surrounding it. With loops of film this is a reasonably rapid operation, but with spooled material a much longer time is required.

THE PROCESSING AND PRINTING OF STANDARD CINÉ FILM

First in point of order and perhaps also in importance, comes the development of exposed negative stock as received from the studios. This is handled with the most scrupulous care, because

should the negative be damaged retakes will be necessary; sometimes it is not possible to obtain such retakes and, if the damage is extensive, the whole film may be rendered useless.

Next must be considered the development of the sound negative. From the two negatives, picture and sound, rush positives are printed so that the producers and camera staff may satisfy themselves

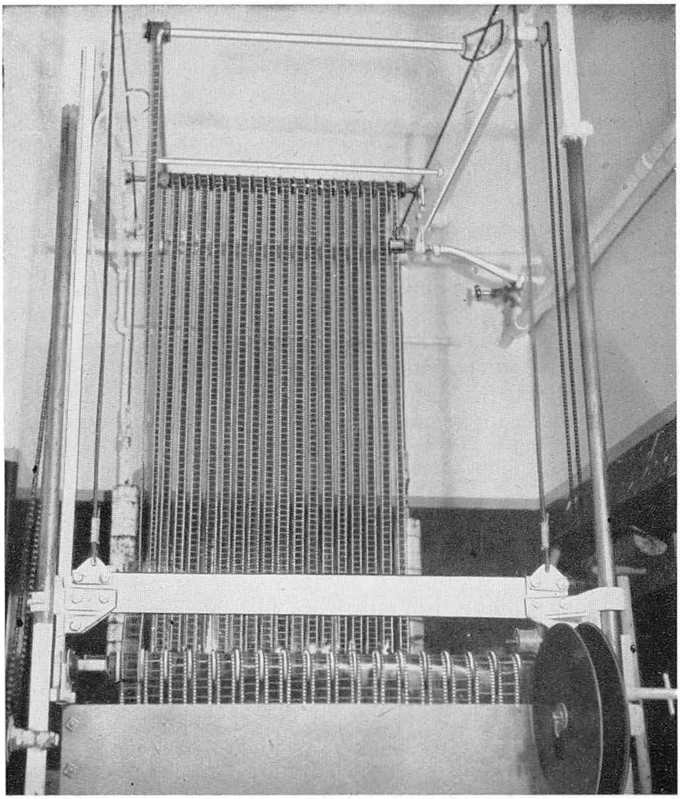


Fig. 119. Processing Tank for 35 mm. Ciné Film.

that their takes have been satisfactory. Then as a safety precaution and for other reasons also, duplicate negatives are made via a dense positive produced on lavender base. Special fine-grained stocks are employed. The release prints may be made directly from the original negative or from these secondary negatives. Where home productions are concerned the usual policy is to print direct from the original negative. Foreign films released in this country, on the

other hand, are generally printed here via duplicate negatives from special prints obtained from the country of origin.

Yet another aspect of the work of the processing laboratory remains to be mentioned. In these days many of the optical effects with which we are familiar on the cinema screen have to be incorporated after the film has been cut and edited, and this work also falls to the lot of the processing-house operatives.

DEVELOPMENT AND DEVELOPING PLANT

Rack and tank methods have been entirely superseded by machines except in cases where only a small footage is handled. At one time developing tanks were charged with 6–8 gallons of developer, now a machine may circulate several hundred gallons. Where machines are used the footage factor has an important bearing on the type of machine best suited for the work. In general, fast development in concentrated solutions is not desirable since it gives rise to grainy results, but, obviously, if the space is limited a compromise may be necessary. This is not a criticism directed at fast-running machines, because provided the length of travel through the tank is sufficient, solutions of normal concentration can be used, and the results are then satisfactory. The conditions which a developing machine must satisfy are many. It must be reasonably easy to operate and to maintain, and must permit of complete control of the development process both as regards speed of operation and addition of replenisher. Machines vary considerably in design. In some machines the film is pulled from tank to tank by sprocket wheels, the film in the tanks being kept under tension by weighted diabolos running on the emulsion side.

DEVELOPING MACHINES

In one particular type of machine manufactured by the Debrie Company, ebonite tanks about 6 ft. deep and 3 in. square in section are arranged in line, and sprocket wheels are located above the tanks in such a way that they pull the film from one tank and pass it over the edges into the next. Weighted diabolos keep the film in tension, but run on the emulsion side, since the sprockets work on the base side of the film.

Each sprocket is driven by a chain wheel through a dog clutch and the chain drive is progressive from the first sprocket shaft. In other words, by declutching at No. 1 sprocket the remaining sprockets come to rest. Similarly, by declutching at sprocket No. 9 the remaining sprockets come to rest, but 1–9 inclusive will continue to revolve. This mechanical arrangement allows the length of loop in any tank to be varied.

Each sprocket shaft is fitted with a handle so that by declutching at a set sprocket and turning the handle of one of the following sprockets, the amount of film in the tank below the declutching point may be reduced, provided the handle is turned faster than the

speed of rotation of the motor driven shafts. If the handle is not turned, the amount of film in the tank in question will be increased.

The capacity of a machine of this type may be adjusted by the number of tanks and sprockets employed, and by the size of the drying cabinet. The speed of running is seldom more than 60 ft. per minute. The tubes are connected by pipes in such a way that the solutions can conveniently be circulated and replenished. In the larger installations, these machines are run in pairs back to back, but the main frame is common to both units.

A rather novel machine also produced by the Debrie Company is capable of running in the daylight. Ebonite tanks are used, but each tank contains many loops of film driven by several rows of roller shafts. On each roller shaft there are flanged rollers in which the usual sprocket teeth are replaced by soft rubber tyres. No sprockets are used in any part of the machine, and compensated tensions are maintained by the rubber tyres which are compressed in diameter when the film becomes tight, and their effective driving speed at the periphery is consequently reduced.

Developing, fixing, washing, and drying tanks are all of the same type. The sinker rollers are mounted on frames, since independent weighting of the loops is not necessary and not practical because of the self-adjusting loop tensions brought about by the rubber tyres. The spiral threading of the film around the drive and sinker rollers ensures its running only on the base side.

The tanks are so formed that the tops may be lifted for inspection purposes and the whole of the front panel of each may be removed with the greatest facility. The film to be processed is contained in a light-proof magazine from which a few inches are allowed to project. This end is joined to the trailing end of the spacing by a clip (no registration of perforations is necessary) and a cradle type reservoir enables the operator to do this while the machine is running. When the end of the roll is about to pass into the machine a clamp closes, holding it so that about a foot projects into the joining chamber, and the operator is able to attach the next roll or leader. Should he fail to do this during the 40 seconds in which the reservoir allows the end to be stopped, a trigger is tripped and the whole machine comes to rest. Visible and/or audible warnings are given at any time the machine is in need of attention, and should a film-break occur the motors are switched off and warnings given.

Automatic solution circulating pumps maintain the solution levels and regulate the addition of strengthening baths. Filling and emptying of the tanks can be carried out automatically. Even the solution lines are fitted with indicators to give warning in the event of any part failing to function properly. A stroboscopic viewer enables the operator to inspect the picture before it enters the drying chambers. Sound may also be checked at the same time, since the normal running speed of the machine is 90 ft. per minute.

The machine next to be described is probably one of the most simple yet effective developing units available. This machine has been designed by Messrs. Vinten, Ltd., in such a way that it may readily be adapted to suit various development processes, including reversal. The developing tank is usually in the form of a large teak

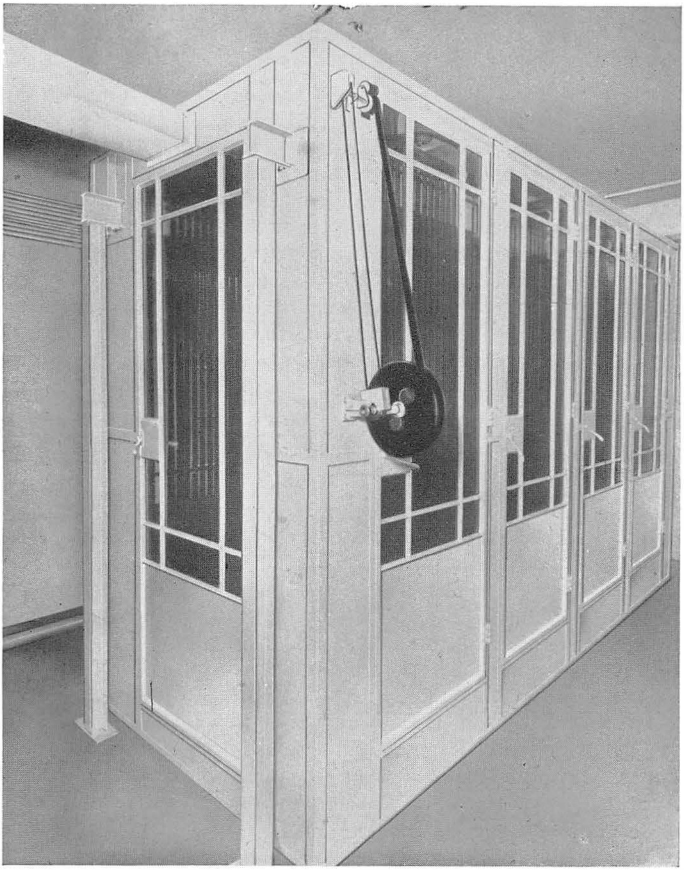


Fig. 120. Vinten 35 mm. Drying Cabinet.

box some 3 ft. wide × 3 ft. high × 6 in. deep, over which runs a sprocket shaft consisting of a number of ebonite rollers and flanges interspaced at suitable intervals with toothed discs. The whole assembly is clamped together and is in effect a row of a dozen or so sprockets fixed together side by side.

The sprocket shaft is capable of being raised completely with its bearing to sufficient height to enable the loops of film to be withdrawn completely from the tank. The film is threaded in the form of a spiral and the loops are kept under tension by means of independent diabolos. The rinsing tank is a small box containing water into which a loop of film passes after leaving the developing section. From there the film rises to a height of 8 ft. or so to the next sprocket. On the outcoming side of the loop a jet of water is sprayed to ensure efficient rinsing.

The fixing section is similar to the developing unit with the exception that the sprocket shaft is fixed in a position about 8 ft. above floor level. This means that there are about 16 ft. of film in the loop, *i.e.*, the loops in the fixing bath are twice as long as the developing loops and this gives adequate fixing time. The washing section is similar to the fixing, but the tanks are shallower and every loop is sprayed with a jet of fresh water. Drying is carried out along a long sprocket shaft with its axis running at right-angles to the developer fixing and washing shafts, and is sometimes enclosed in a steel and glass cabinet according to the user's requirements.

Development time is regulated by means of a speed control on the motor. The whole machine is so adaptable that not only does it occupy the minimum of space, but it need not be completely installed on one floor of the building, since it is quite a simple matter to pass the film in any direction from one section to the next.

On yet another type manufactured by the Lawley Company the automatic-processing plant consists of tubular tanks with geared sprockets to carry the film from one to the other. In some processing houses machines of this kind have been installed in which the tanks pass through two or even three storeys, thus enabling high processing speeds to be attained whilst maintaining the operating or top section of the machine in a compact form. Drying is carried out either in metal tubes or in the conventional drying cabinet. In its latest form the Lawley machine is constructed with large tanks through which the film passes in helical loops on a number of multiple sprocket shafts and in which the developing and fixing processes are carried on. Washing is effected in tubes and drying in a cabinet of special design. Provision is made for adequate turbulation. Processing speeds with the machine may be varied between 120 ft. per minute for 5 minutes developing time (positive) and 50 ft. per minute for 12 minutes (negative) or less.

GENERAL

Many laboratories have constructed machines particularly suitable for their individual requirements. In modern high-speed plants the favoured system seems to be the large square tank filled with several rows of loops from parallel roller shafts. Sprocket teeth

are not used on high-speed machines, since the liability for them to get out of mesh becomes pronounced above about 60 ft. per minute.

Where the film is moved in the machine by power-driven sprockets, elevators are necessary to allow for changes in tension due to shrinkage or swelling. With friction drive, on the other hand, no allowance need be made, but the advantages and disadvantages of these two systems form subject matter for a highly controversial discussion which cannot be entered into here. It should be noted that the conditions in a developing machine are not exactly comparable with those in a projector or a printer, since sprocket clamp rollers are not used and the spiral formation of the loop is more difficult to handle than when the film is running at right-angles to the axis of the sprocket.

Many of the earlier developing machines were prone to produce directional effects due to inhibition of development by local concentrations of soluble bromides. In modern machines this difficulty has been obviated by means of turbulation.

REPLENISHERS

In the modern developing plant arrangements are made for adding a replenisher to the developing bath so that its useful life may be prolonged as much as possible. Some laboratories prefer to add solution of the same composition as the original developer. Others omit the bromide and occasionally the carbonate content is modified.

(1) THE PICTURE NEGATIVE

The processing of the picture negatives is conditioned firstly by the requirements of the photographic process in general, and, secondly, by the nature of the negative emulsion itself. For correct tone reproduction by photography two things are essential: (*a*) exposures should have been made on the straight-line portion of the characteristic curves of both negative and positive; (*b*) the products of the gammas of the negative and the positive must be approximately unity.

This product could, of course, be obtained for many values of negative gamma, but from considerations of graininess, negative gamma is kept low. In general, the faster the material, the greater the inherent graininess; but graininess is also conditioned by the amount of development which the emulsion has received. Negative emulsions are much faster than positive stock, and, therefore, they are more prone to grain. For this reason picture negative is developed for a fairly long time in a slow working M.Q. borax bath to a low gamma, normally about 0·65. The positive, on the other hand, is developed to a gamma of approximately 2 to achieve the necessary product.

There are two methods of controlling negative development:—

(*a*) The film is developed to a definite gamma according to the results of sensitometric strips put through the machine at frequent intervals.

(*b*) The film is developed according to the results obtained on camera test lengths. On this system the cameraman shoots an extra short length of each scene, this short length being developed separately and examined visually. On the basis of the results obtained the negative representing the scene is developed.

Even where the first system is in operation some laboratories prefer to put through a picture test (usually a portrait) as well as the strips. Where the sensitometric strip system is in operation it is essential for the cameraman to acquaint the operators at the processing house with the effects he has been trying to produce, otherwise the processing department may over-develop in order to correct for an apparent under-exposure which was quite intentional.

(2) THE SOUND NEGATIVE

As with the picture negative, the laboratory's responsibility begins and ends with the processing; the recording and re-recording being usually done in the studios. The processing, however, does depend on the recording method used.

THE PRODUCTION OF THE SOUND NEGATIVE

The essential condition for correct sound reproduction is that the transmission of the positive shall be proportional to the exposure received by the negative.

In the variable-density system the recorder consists of a light valve with an opening defined by metal ribbons. Amplitude variations result in the closing and opening of these ribbons, the maximum opening being twice the width of the normal unmodulated opening.

In this case correct reproduction depends on the image densities and it is necessary to develop the negative so that the product of the negative gamma and the positive gamma will be unity when the various correcting factors have been applied.

The negative film is developed to a gamma of from 0·35–0·40 and the density of unmodulated track without biasing current is usually 0·50–0·60. In the positive print the unmodulated track density should be between 0·65–0·75. In practice the toe of the curve is often used in the recording, at least to some extent, and compensation for this has to be made during printing when the positive can purposely be made to introduce distortion equal and

opposite to that due to the negative toe. In the variable area system photographic gradation does not come into the matter.

In the variable-area system recording is done by an oscillograph which is essentially a galvanometer. Between the poles of a permanent magnet there is a mirror which vibrates with the current from the amplifier and moves a beam of light across a slit which is of fixed dimensions and position. The light transmitted by the slit is focussed upon the film to produce a line image extending across the sound track width, the length of the line depending upon the amplitude of the original sound. The effect is to produce on the moving film a continuous image of varying width. Since the transmission of the track at any point depends on the ratio of black to clear, in this case a contrasty emulsion is required and the negative is usually developed to a gamma of about 2. A negative density in the black area of 1·4–1·5 has been found to be ample. The positive is exposed to give a density in the "black" areas of about 1·3 when developed to the normal print gamma of 2–2·2. This density is especially suitable since this is the condition for optimum resolving power. For ultra-violet recording a negative density of 1·90 and a positive density of 1·40 are advised.

Variable-density toe-recording utilizes the under-exposure region of the characteristic curve and the source of light is usually a discharge tube. Speech currents cause the brightness of the glow to fluctuate, care being taken that the variation neither overloads the lamp nor causes it to be extinguished. For recording by this method a contrasty emulsion is required, and, since the intensities available are low, the emulsion must also be fast.

Scratches and specks of dirt can give rise to objectionable noise, particularly in quiet passages, unless steps are taken to reduce the track transmission to low values during such passages. This is effected by applying a biasing current to the oscillograph, the light valve or the discharge tube. As soon as modulation recommences, this biasing current is automatically cut down and the mean track transmission is brought back correspondingly nearer to the 50 per cent. value required to allow full modulation to take place. This variation in track transmission is the basis of all noiseless recordings.

In general, sound recording negative develops up much faster than does picture negative, and for this reason development time is much less. In fact, when recording has been done on the variable-density system it is almost impossible to secure a short enough development time with a normal borax bath, and a half-strength bath is frequently used. For a development time of 8 minutes for picture negative in a full-strength bath, 3 minutes in a half-strength bath is usually ample for variable density sound negative. Variable-area track is usually developed in a positive bath for from 6 to 12 minutes, since, as we have seen, fairly high contrast is desirable.

OTHER STOCKS

The Positive Print. This is developed in a good contrast-giving metol-hydroquinone developer to a gamma of between 2 and 2·2. Sensitometric tests or test prints are used as a check on the performance of the developing bath.

Duplicating Stocks. In the main it can be said that the master positive is developed in the ordinary positive developer to a gamma of about 2, and the negative in an M.Q. borax bath to a gamma of about 0·65, but with the special duplicating stocks now available it is advisable to adhere closely to the recommendations of the manufacturers.

THE PRINTING ROOM AND EQUIPMENT

The printing room is generally maintained at 70°F. (21°C.), and 65–70 per cent. relative humidity. In modern laboratories the air is in continual process of circulation. A positive pressure is maintained in all the rooms and the exhaust air is admitted to a chamber where its temperature is readjusted and where it is mixed with newly filtered air added to make good the losses in the system. The air is then forced into the water-spray chamber, where it is washed and brought to the correct temperature and humidity. From this chamber it is forced into the ducts and distributed.

PRINTERS

Printing machines are of four types: Contact Step; Contact Continuous; Optical Step; Optical Continuous. These will be described in rotation.

Contact Step Machines. Due to their comparatively low speed and to the fact that the continuous type of printer is necessary for sound, machines of the contact step type have become uncommon in this country and in America. On the Continent the insertion of superimposed titles to obviate difficulties of language requires special accessories which are most easily applied to step printers, and for this reason they are still commonly used. They enable accurate registration to be maintained and this registration is not affected by reasonable shrinkage of the film. For this reason printers of this type are often used for duplication, especially from old negatives. Step printers work at between 20 ft. and 70 ft. per minute.

Combination step-picture-head and continuous-sound-head printers are quite practicable, and are very popular, especially on the Continent.

Contact Continuous. This system was adopted by the Bell & Howell Company many years before the advent of sound on film. The positive and negative films were made to come into contact on a large diameter sprocket wheel in the middle of which was the exposing light source. The diameter of the sprocket was calculated

so that the difference between the radii of the negative and positive arcs was enough to allow for an average shrinkage of the negative. The advent of sound helped to make machines of this type popular. In many modern machines the films are drawn over a curved gate by a sprocket of high precision, the curvatures of the gate being made to correct at least partially, for negative shrinkage. Gates are generally interchangeable, so that sound or mute negatives may be printed head first or tail first.

In general these machines are coupled in pairs in order to handle sound and mute simultaneously. Backward and forward printing models are in existence. In one of the most recent types, the film is totally enclosed, can run in both directions, and is automatically cleaned; it is claimed that after 100 prints have been taken, no signs of wear or tear are noticeable in the negative.

Optical Step Machines. These machines are divided into two main classes, *i.e.*, 35 mm.—35 mm. printers for trick work and duplication, and 35 mm. reduction to sub-standard sizes.

35 mm.—35 mm. Optical Printers. Wherever it is desirable to incorporate some slight change in the print, such as the substitution of the academy mask for the old silent mask, and for trick work generally, printers of this type are in demand. Several standard machines are available, but in many cases equipment is specially made to order. In one fairly recent example, by splitting the light beam five positive prints are taken simultaneously from the mute and sound negatives. The machine runs at 5,400 ft. per hour per head, with a total output of 27,000 ft. of positive film per hour.

In some machines high-grade cinematograph cameras are converted for use as printer heads in order to ensure accurate registration. Where it is desired to print the modern academy mask from old silent negatives an adjustment of film speed is made to enable projection to be carried out at the normal speed of 24 frames per second without acceleration of motion, and this result is arrived at by printing each alternate frame twice, thus adding 50 per cent. more frames tot he positive than are present on the negative.

Reduction Printers. In making silent reduction prints from 35 mm. negatives the sound tracks are merely cut out. For the production of 16 mm. sound film by reduction, however, it is necessary to change the dimensions and proportions of the sound track, which must be compressed in length and in width, but the reduction in width is less than that in length to preserve volume. The unequal compression in two directions at right-angles is carried out by means of a cylindrical lens. It should be noted that the picture reduction printing may be, and often is, carried out by means of a step printer. The reduction printing of the sound tracks, like straightforward sound track printing, must be done on a continuous machine.

Sometimes two 16 mm. films are printed side by side on 32 mm. stock, the light beam being split to form two images, so that the two 16 mm. copies are made simultaneously. The stock is split either immediately after printing or after processing. Light changes are generally automatic and similar in arrangement to those fitted to standard 35 mm. machines. One American company has produced a reduction printer capable of handling 35 mm.–16 mm., 16 mm.–35 mm., 16 mm.–16 mm. contact, and 35 mm.–35 mm. optical printing. Two lamp houses are fitted, one above the 35 mm. gate and one below the 16 mm. gate, so that the change over from reduction to enlargement can be rapidly effected.

Optical Continuous Machines. The printing of sound tracks is responsible for perhaps the greatest loss of quality throughout the whole process of sound film production. Mechanical errors in machinery and film stock cause the obliteration of high-frequency note records, "flutter," "wow," and other objectionable effects common in sound film reproduction.

Re-recording enables many of these defects to be eliminated, since high-grade reproduction and recording heads are specially constructed to eliminate distortion. Mechanical filters and constant speed devices ensure steady motion of the films. The latest modifications in sound film printing machinery have been derived from the re-recording system, but the electrical link is replaced by an optical one. Two sound film recording heads are run at synchronous speeds. The light valve recording gear is removed and in its place there is fitted a light source to throw a beam through the negative sound track, the image being re-formed by means of a lens on the positive stock running in the second head. Sound film reduction printing has been carried out in a similar way, and some of the best 16 mm. records made to date have been done by this method.

GRADING THE NEGATIVE FOR PRINTING

The preparation of a positive print from a negative record would be perfectly straightforward if the original negative were quite even throughout as regards exposure. Where the printing is being done from a duplicate negative, care is generally taken to ensure that the duplicate negative is so balanced. When the printing, however, is being done directly from an original negative, this is never the case.

In general the negative will vary in average density from scene to scene, and to ensure a balanced print which will not show violent fluctuations from light to dark on the screen, it is necessary first of all that the original negative be graded from scene to scene, and, secondly, that the printer should incorporate some system of light change.

For the most part the grading operation is not done automatically, but on the basis of visual examination by a skilled operative. In some cases, however, and often as a check, a machine of the Cinex

type is employed. In this case a short strip from each scene is printed on a sample of the positive stock which is to be used. Printing of each of these scenes is done at a series of different light intensities, and by examining the final results the operator decides which light intensity is the correct one for that particular scene.

A further refinement which is being attempted at the present time and which may yet displace the other systems, employs a photo-electric cell. The aim of machines of this type is to estimate automatically the "average printing density" of the particular scene. As can be seen, however, this particular method is open to very grave complications.

As far as the light changes are concerned they are best made to represent logarithmic increments, and in general eleven changes at least should be available. The changes themselves may be either semi- or completely automatic, and may be made either by means of a mechanical shutter by specially prepared mattes, or by altering the voltage on the printing lamp. The last means of control must be used with discretion, since it involves a change in the colour temperature of the lamp, and this, if carried too far, will cause changes in gamma. Printer lamps should be of greater voltage than is strictly necessary, so that they may be under-run to enable the colour temperature to remain constant throughout the working life of the lamp.

Whatever system of grading is employed, a grading record must be made in a form suitable for the particular light-change system in use on the printing machines. The principal light-change systems together with other appropriate methods of making and grading records are described in detail.

(1) **Bell & Howell System.** In machines of this type the light changes are effected by means of a shutter which is moved across the printer gate. The mechanism is semi-automatic. Notches are cut on the edge of the negative where light changes are necessary, and the actual change to be brought about is pre-selected by the operator during the printing of the previous scene. The change comes into effect as soon as the next notch is reached.

(2) **Debrie System.** The negative is notched as for the Bell & Howell method, but in addition a strip of 35 mm. stock is punched with slots according to a code representing various light values. Each time a negative notch passes a switch device in the printer gate, the light-change control film is moved to a new slot. Small feeler contacts enter the slots and short-circuit sections of a resistance run in series with the printer light. On the Debrie "quintuple" printer, where all movements are continuous, no notches in the negative are necessary, because the perforated light-control film is made to run continuously at one-twentieth the speed of the negative, and is synchronized to effect the light changes at the desired time.

(3) **Lawley System.** Before entering the printing gate, the negative passes through a contact gate with rails over which the perforated margins run, divided into alternate metal and fibre sections to form a commutator. The insertion of small nickel clips through and between consecutive perforations in the film allows contact to be made between the commutator rail and the solid pressure skid. By arranging the relative position of two clips contact is made from a master section to another section connected to a resistance. There are twelve such contact points in the commutator, one being the master and the remaining eleven being connected to various points on the light-control resistance, thus giving a range of eleven light changes. In order to facilitate the spacing of the clips, a special device is available for their insertion, having a chart drawn out upon it to indicate to the operator the exact position for the necessary light changes. It is interesting to note that this little machine cuts the clip from a roll of metal ribbon, passes its end through the perforations and folds them into a flat loop. When the clip is inserted, its ends touch to form a complete loop, but it is just free to move, so that it cannot damage the negative in any way. Another device is available for its rapid removal without damage to the perforations. In the printing machine the printing sprocket has its alternate teeth removed and the backs of the remaining teeth machined away in such a manner that a clip never comes into contact with a tooth, and thus does not cause distortion of the image in printing. The contact made by the clip allows a low-voltage current to flow to an electro-mechanical relay system, which, in turn, operates the light change by short-circuiting sections of the main resistance.

(4) **Vinten System.** This is similar to the Debrie "quintuple" method, but employs a strong paper strip of 75 mm. width, travelling at one-hundredth the speed of the negative, the light value being changed by means of a resistance.

SUB-STANDARD CINEMATOGRAPHY

The cost of apparatus and film required for the production of motion pictures was, for many years, an insuperable obstacle to the taking and showing of such pictures by private persons. The introduction of film of narrower widths, and of cameras and projectors adapted for them, has, however, brought cinematography within the means and convenience of the individual and has created an immense number of users of such "sub-standard" apparatus for purposes of recreation, commerce, research, etc. The ciné-camera may be smaller and lighter than an ordinary hand camera and may cost less than many an instrument for taking "still" pictures, and projectors capable of showing entirely satisfactory moving pictures in the user's home may be had for less money than was formerly paid for a good optical lantern. Libraries

from which films may be hired allow the ciné-amateur to supplement films of his own taking by those of many of the world-famous productions. Sub-standard cinematography, in short, is a branch of photography now firmly established on account of its extreme simplicity, moderate cost and multifarious applications.

SUB-STANDARD FILMS

For use with the wide variety of sub-standard apparatus available to the amateur there is manufactured to-day a complete range of sub-standard films to cover all branches of cinematography, including colour and sound. For the sake of safety, all sub-standard films, without exception, are coated on acetate base which is practically free from fire risks. The most popular sizes are the 16 mm., 9·5 mm., and 8 mm. widths. The more serious work is usually undertaken on the 16 mm. size, which is rapidly gaining popularity among professional cinematographers for commercial work, research, and publicity purposes. 16 mm. films, like their 35 mm. prototype, have perforations along their outside edges, by means of which they are drawn by sprocket teeth and claws through the camera, projector, or other apparatus. The actual picture area is 10·5 × 7·62 mm., and modern emulsion and projection equipment allow this small frame to be enlarged to fill a screen with a picture as much as 12 ft. in width.

The 9·5 mm. size is popular for its cheapness, the low price of apparatus, and for the reasonably large magnification which can be obtained at a relatively low cost. The negative stock for the camera is usually packed in small cassettes containing about 30 ft. of film, allowing daylight loading, and facilitating the despatch of the film to the processing house for development. Unlike 35 mm. and 16 mm. practice, the perforations are punched down the centre of the film and occupy the space between successive frames, known as the "frame line."

8 mm. films are derived from a 16 mm. strip split into halves, but having twice as many perforations along the edge. The frame size is half the width and half the height, and, therefore, a quarter the area of a 16 mm. frame. In the system known as double 8 a special 16 mm. film is used in the camera. Exposure takes place on only one half of the picture area, and after the roll has run through the camera it is turned over for exposure on the other half. After processing, the film is slit and works in a normal 8 mm. projector. As a given area of film contains four times as many 8 mm. pictures as it would 16 mm. frames, the compactness of the system will be readily appreciated.

A taking and projection speed of 16 frames per second is normal for all three types of film mentioned above, except in the case of 16 mm. being used for sound when the speed is increased to 24 frames per second.

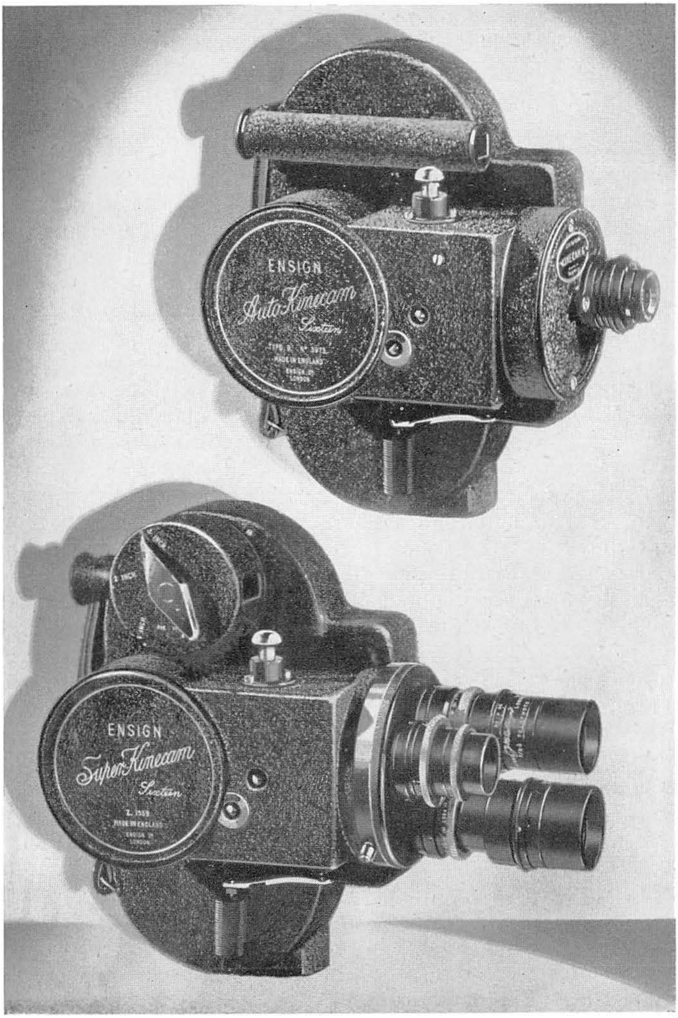


Fig. 121. Ensign 16 mm. Auto-Kinecam and Super-Kinecam.

CINÉ CAMERAS

The large number of cameras available for the exposure of sub-standard films is evidence of the widespread use of these instruments for recreative and more serious purposes. Generally speaking, the more elaborate models are to be found in the 16 mm. class, and it

would seem that this size is generally adopted by those making ciné films for business purposes, for which, frequently, films are sent to a firm's agents in foreign countries, where the performance of machines or the stages of an industrial process may be shown to prospective customers. In each size class, cameras may be had with additional facilities, such as lenses of various focal lengths and a device for the taking of slow-motion pictures. In most cases the film is driven by a clockwork motor and, as the time of exposure of each separate picture is fixed at approximately 1/30th of a second by

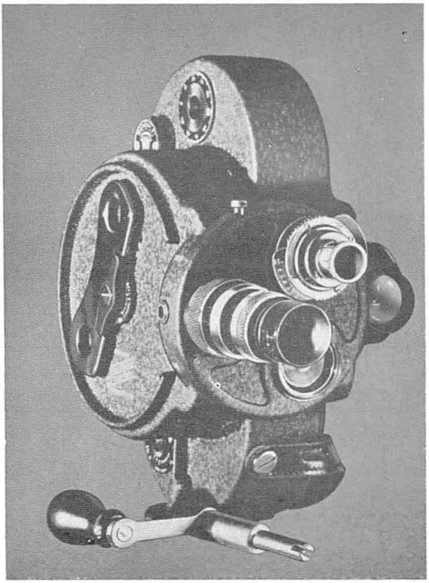


Fig. 122. Bell & Howell 16 mm. Film 70 D.A. Camera.

the operation of the intermittent mechanism, allowance for variation of the prevailing light is made by using a larger or smaller lens aperture. Such estimation of "exposure" is the only calculation which enters into the use of the camera, since the short focus of the lens usually fitted renders focussing unnecessary. Hence all the user has to do is simply to sight his subject in the finder, start the motor and continue to view the action in the finder while the film is running. In other models, fitted with lenses of longer focus, focussing scales are provided and also finders which show the picture obtained.

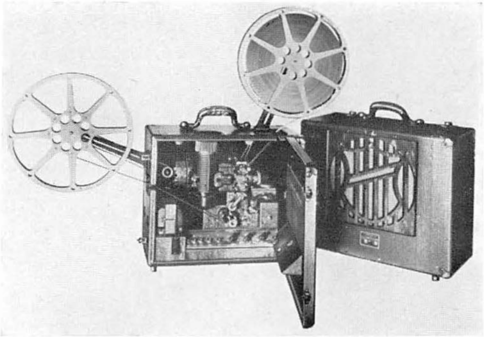
Fig. 123. Bell & Howell Filmo 8 mm. "Sportster" Camera.

CINÉ PROJECTORS

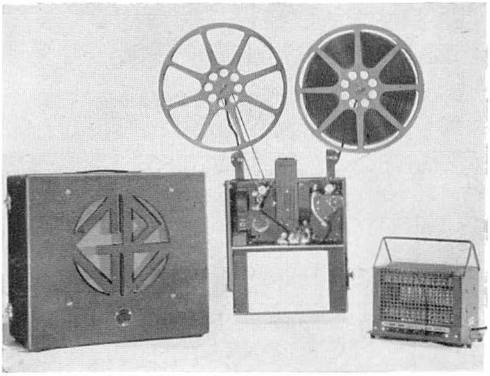
An equally large range of apparatus for the projection of narrow films is also available. Instruments differ chiefly in the power of the lamp used and in the refinements, such as the devices for re-winding, automatic framing, showing "still" pictures, and in the electrical arrangements for use of current of any voltage for running the lamp and driving the film. Once again, the 16 mm. size offers the greatest variety of equipment, and lamp sizes vary from about 100 watts in the case of the smaller and cheaper models, up to 1,000 watts in the machines built to fulfil the requirements of the professional worker. At least two firms have placed on the market 16 mm. projection mechanisms fitted with special lamp houses containing an arc lamp, and it is these machines which are capable of filling large screens with a very brilliant picture. Owing to the great heat in the light beam where it passes through the film, it is customary to fit such projectors with a blower or cooling device in order to reduce the risk of scorching the film.

CINÉ-FILM EMULSIONS

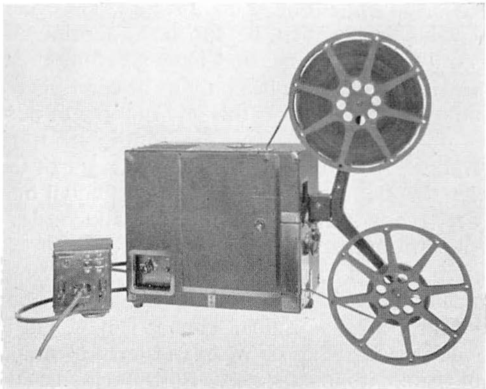
Just as a "still" photographer produces a negative from which any number of prints can be made, so in 35 mm. cinematograph practice positive copies for projection are printed from the negative



Bell & Howell 16 mm. Filmo-Sound "Master" Projector.



Gebescope L.516 Sound and Silent 16 mm. Projector.



B.T.H. 16 mm. Sound Film Projector and Mains Transformer.

Fig. 124.

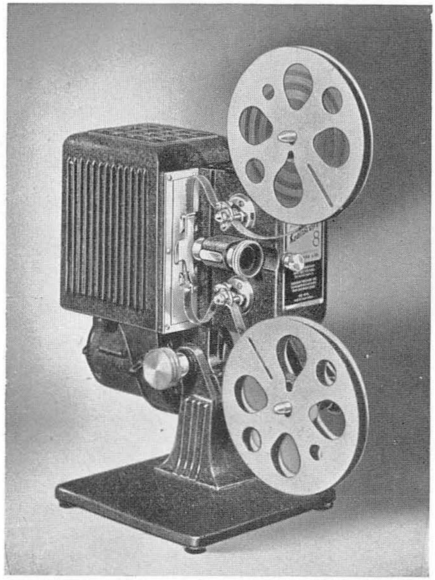


Fig. 125. Home Kodascope 8 mm. Projector.

exposed in the camera. The sub-standard worker has, however, two alternatives for the production of a projection print: (1) by taking on negative material and having copies printed therefrom, or (2) by using a reversal material which, after exposure, is chemically reversed into a positive. The serious worker will, undoubtedly, find the former method to have many advantages which allow him to follow professional practice. For instance, in order to avoid damaging a valuable negative, he can have a print made for the purpose of cutting and editing, and having arranged his scenes in the desired order, the negative has only to be carefully matched and cut to the same sequence. After this any number of positive copies can be taken off and the negative stored until such time as further prints are required. It is obvious that in the event of the first print or prints becoming damaged, further copies of equal quality can be readily made at any time. The reversal system is, of course, extremely simple from the user's point of view. His stock is exposed in the camera, returned to the processing house, reversed and sent back to him as a finished positive print. Satisfactory copies can be made by reversal from the original when it is new, but in the event of damage, such as scratches or wear and tear of the perforations, the quality of the copies must suffer. Both for the negative positive

and the direct reversal systems, fast panchromatic emulsions permit adequate exposure under conditions of poor lighting and accurate colour tone rendering. When it is necessary to produce a number of copies for libraries, etc., it is often found desirable to make duplicate negatives, and for this purpose master positive and duplicate negative emulsions are coated and manufactured in sub-standard sizes. In the case of a professional 35 mm. film being used for 16 mm. sub-standard copies, the processing house employs a reduction printing machine which optically reduces the frame size down to the required dimensions.

EXPOSURE

The average time of shutter opening in a ciné camera working at 16 frames per second is 1/30th of a second. It is necessary, therefore, only to judge the required lens aperture and for the aid of both professional and amateur alike, photo-electric exposure meters capable of giving speedy and accurate readings of light values are available at a reasonable cost.

TALKING FILMS

The technicalities of photographic sound recording and reproduction are, generally speaking, so complicated as to be beyond the scope of the amateur, but 16 mm. cameras have been made combining a sound-recording head by means of which the user is able to record a sound track synchronized with the picture. The film for this purpose has perforations along one edge only, the blank margin being used to carry the sound track. Unfortunately, the emulsion which is ideal for picture negatives is not entirely suitable for sound recording purposes, but, nevertheless, interesting results of reasonably good quality can be obtained. Generally speaking, sub-standard sound films are produced by reduction from 35 mm. originals, and in this way the quality of sound reproduction can be made to achieve a high order.

It has been already stated that with the advent of photographic sound records the taking and projection speed of a 35 mm. film was increased from 16 to 24 frames per second, giving a linear film speed of approximately 18 in. per second. When it is understood that for first-class sound reproduction it is necessary to record up to 10,000 vibrations a second, it will be readily seen that the higher the velocity of the film the less minute will be the recorded images of these peaks and, therefore, the greater the chance of maintaining definition. The linear speed of a 16 mm. film running at 24 frames per second is only 2/5ths of the 35 mm. speed, but by careful manipulation it is normal to preserve frequencies up to six or seven thousand cycles per second.

CHAPTER XXV

USEFUL FORMULÆ

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To provide an easy method of reference we have classified in this chapter the various formulæ given in the preceding chapters under appropriate headings and, in addition, have included formulæ recommended for special work. It is felt that this will be of assistance to photographers who will have in easily accessible form the whole range of Ilford formulæ.

MAKING UP SOLUTIONS

The figures for Avoirdupois and Metric systems are not interchangeable, but the finished solutions have approximately the same composition.

Dissolve the chemicals in the order given, except where otherwise noted, using about three-fourths of the water required. The water should be hot, then add cold water to make up the full amount.

ANHYDROUS SALTS

Where anhydrous salts are used instead of crystal, the following equivalents may be used:—

Sodium sulphite (cryst.) ..	100 parts	= 50 parts anhydrous
Sodium carbonate (cryst.)	100 ,,	= 37½ ,, ,,
Sodium carbonate (monohydrate)	100 ,,	= 85½ ,, ,,

TEMPERATURE FOR DEVELOPMENT

The development times given are for a temperature of 65°F. (18°C.).

DEVELOPERS FOR PLATES OR FILMS

Ilford Certinal

The Ilford Concentrated Liquid Developer for plates and films requires the addition of water only.

For Dish development, dilute 1 part with 15 parts water.
,, Tank ,, ,, 1 ,, ,, 30 ,, ,,

ID-1. Ilford Pyro-Soda Developer

STOCK SOLUTION

Pyrogallic acid	1 oz.	or	25 g.
Potassium metabisulphite	100 gr.	or	6 g.
Water, up to	10 oz.	or	250 c.c.

The potassium metabisulphite should be first dissolved in the water previous to adding the pyro.

WORKING SOLUTIONS

A

Pyro Stock Solution ..	2 oz.	or	50 c.c.
Water, up to	20 oz.		500 c.c.

B

Sodium carbonate (cryst.)	2 oz.	or	50 g.
Sodium sulphite (cryst.)	2 oz.		50 g.
Potassium bromide (10 per cent. solution)	2 dr.		6 c.c.
Water, up to	20 oz.		500 c.c.

Dish: For use, mix equal parts of A and B.

Tank: For use, mix 1 part stock solution, 5 parts B and water 20 parts.

ID-2. Metol-Hydroquinone (M.Q.) Developer

STOCK SOLUTION

Metol	20 gr.	or	1 g.
Sodium sulphite (cryst.)	3 oz.		75 g.
Hydroquinone	80 gr.		4 g.
Sodium carbonate (cryst.)	2 oz.		50 g.
Potassium bromide	20 gr.		1 g.
Water, up to	20 oz.		500 c.c.

Dish: For use, dilute 1 part with 2 parts of water.

Tank: For use, dilute 1 part with 5 parts of water.

Supplied in tins to make 10 oz., ½, 1, and 2½ gallons of stock solution.

ID-3. Metol

Gives soft gradation with maximum shadow detail. Development is slow, but the speed may be modified by altering the dilution.

Metol	50 gr.	or	3 g.
Sodium sulphite (cryst.)	1 oz.		25 g.
Sodium carbonate (cryst.)	2 oz.		50 g.
Potassium bromide	10 gr.		0·5 g.
Water, up to	20 oz.		500 c.c.

For use, dilute 1 part with 3 parts of water.

ID-4. Pyro-Metol

An exceedingly energetic developer intended for plates which have received minimum exposures. On account of the yellowish colour of the image even very weak negatives may have good printing contrast.

A

Metol	35 gr.	or	2 g.
Potassium metabisulphite ..	100 gr.		6 g.
Pyrogallic acid	100 gr.		6 g.
Water, up to	20 oz.		500 c.c.

B

Sodium carbonate (cryst.)	4 oz.	or	100 g.
Water, up to	20 oz.		500 c.c.

For use, mix equal parts of A and B.

ID-9. Amidol

This is a good all-round developer. It requires no alkali, but the sulphite is essential.

Sodium sulphite (cryst.)	4 oz.	or	100 g.
Amidol	175 gr.		9 g.
Potassium bromide	50 gr.		2 g.
Water, up to	20 oz.		500 c.c.

This developer keeps only for a day or two, any left over being useless.

DEVELOPERS FOR BULK D. & P. WORK

ID-6. Ilford P.M.Q.

Metol	1 oz.	or	25 g.
Sodium sulphite (cryst.)	1¾ lb.		700 g.
*Sodium bisulphite	1 lb.		400 g.
Hydroquinone	5½ oz.		135 g.
Pyro	1 oz.		25 g.
Sodium carbonate (cryst.)	5 lb.		2000 g.
Potassium bromide	50 gr.		2 g.
Water, up to	10 gall.		40 l.

Dissolve the chemicals in the order given in about 7 gallons of warm water and make up to 10 gallons with cold water.

The developer should be kept up to bulk by the addition, as required, of the strengthener diluted with an equal bulk of water.

STRENGTHENER

Metol	½ oz.	or	12·5 g.
Sodium sulphite (cryst.)	½ lb.		200 g.
*Sodium bisulphite	¼ lb.		100 g.
Hydroquinone	1½ oz.		37·5 g.
Sodium carbonate (cryst.)	1½ lb.		600 g.
Water, up to	1 gall.		4 l.

This developer is supplied in boxes to make 10 and 12 gallons, and 2 gallons of strengthener.

ID-34. Ilford M.Q.

Metol	1 oz.	or	25 g.
Sodium sulphite (cryst.) ..	2 lb.		800 g.
*Sodium bisulphite	4 oz.		100 g.
Hydroquinone	5 oz.		125 g.
Sodium carbonate (cryst.) ..	2½ lb.		1000 g.
Potassium bromide	½ oz.		12·5 g.
Water, up to	10 gall.		40 l.

* *An equal weight of potassium metabisulphite may be substituted for the sodium bisulphite if desired.*

STRENGTHENER

Metol	$\frac{1}{2}$ oz.	or	2·5 g.
Sodium sulphite (cryst.)	$6\frac{1}{4}$ oz.		156 g.
*Sodium bisulphite	$\frac{3}{4}$ oz.		18·5 g.
Hydroquinone	$\frac{1}{2}$ oz.		12·5 g.
Sodium carbonate (cryst.)	$\frac{1}{2}$ lb.		200 g.
Water, up to	1 gall.		4 l.

FINE GRAIN DEVELOPER

ID-11. For Miniature and Ciné Films

Metol	20 gr.	or	1 g.
Sodium sulphite (cryst.)	4 oz.		100 g.
Hydroquinone	50 gr.		2·5 g.
Borax	20 gr.		1 g.
Water, up to	20 oz.		500 c.c.

This developer is used at full strength, the times of development for Ilford Plates and Films being the *Tank* times given on page 195. For greater contrast these times may be increased by as much as 50 per cent.

Supplied in tins to make 20 oz., 80 oz., 1 gallon, and 3 gallons, working strength developer.

DEVELOPERS FOR PHOTO-MECHANICAL WORK

ID-13. For Screen or Line Negatives and Positives

A

Hydroquinone	1 oz.	or	25 g.
Potassium metabisulphite	1 oz.		25 g.
Potassium bromide	1 oz.		25 g.
Water, up to	40 oz.		1000 c.c.

B

Potassium hydroxide (stick or pellet)	2 oz.	or	50 g.
Water, up to	40 oz.		1000 c.c.

For use, mix equal parts of A and B. With normal exposure development should be complete in about two minutes.

ID-2. For Continuous Tone Negatives and Positives

Metol	40 gr.	or	2 g.
Sodium sulphite (cryst.)	6 oz.		150 g.
Hydroquinone	160 gr.		8 g.
Sodium carbonate (cryst.)	4 oz.		100 g.
Potassium bromide	40 gr.		2 g.
Water, up to	40 oz.		1000 c.c.

For use, dilute 1 part of the above with 2 parts of water. Time of development 3–6 minutes according to the contrast required.

Supplied in tins to make 10 oz., $\frac{1}{2}$, 1 and $2\frac{1}{2}$ gallons of stock solution.

* *An equal weight of potassium metabisulphite may be substituted for the sodium bisulphite if desired.*

ID-14. Metol-Hydroquinone Contrast Developer

Metol	30 gr.	or	1·5 g.
Sodium sulphite (cryst.)	6 oz.		150 g.
Hydroquinone	½ oz.		12·5 g.
Sodium carbonate (cryst.)	4 oz.		100 g.
Potassium bromide	40 gr.		2 g.
Water, up to	40 oz.		1000 c.c.

Use at above strength and develop 2–4 minutes according to contrast required.

ID-15. Metol Developer for Soft Negatives and Positives

Metol	60 gr.	or	3 g.
Sodium sulphite (cryst.)	1¾ oz.		40 g.
Sodium carbonate (cryst.)	2 oz.		50 g.
Potassium bromide	10 gr.		0·5 g.
Water, up to	40 oz.		1000 c.c.

For use, dilute with an equal volume of water.

Expose fully and develop for 2–6 minutes according to contrast required.

ID-35. Hydroquinone-Carbonate Developer

A

Hydroquinone	3 oz.	or	75 g.
Sodium sulphite (anhyd.)	7½ oz.		188 g.
Potassium bromide	¾ oz.		18 g.
Water, up to	80 oz.		2000 c.c.

B

Potassium carbonate (anhyd.)	10 oz.	or	250 g.
Water, up to	80 oz.		2000 c.c.

For use, take equal parts of A and B.

X-RAY AND OSCILLOGRAPH DEVELOPERS

ID-19. X-ray Developer

Developer for Dish or Tank

Metol	80 gr.	or	4 g.
Sodium sulphite (cryst.)	12 oz.		300 g.
Hydroquinone	320 gr.		16 g.
Sodium carbonate (cryst.)	8 oz.		200 g.
Potassium bromide	200 gr.		10 g.
Water, up to	80 oz.		2000 c.c.

Wash for one minute before fixing.

Supplied in tins to make ½, 1, 2, 3, 5, and 10 gallons.

A one-gallon Replenisher packed in two 80-oz. units is available for ID–19 developer.

ID-33. Oscillograph Developer

Metol	100 gr.	or	5 g.
Sodium sulphite (cryst.)	4 oz.		100 g.
Hydroquinone	160 gr.		8 g.
Sodium carbonate (cryst.)	4 oz.		100 g.
Potassium bromide	100 gr.		5 g.
Water, up to	40 oz.		1000 c.c.

Time of development, 5–10 minutes.

Supplied in tins to make ½ and 2 gallons of working strength developer.

DEVELOPERS FOR LANTERN PLATES AND TRANSPARENCIES

ID-16. For Ilford Special Lantern Plates

HYDROQUINONE DEVELOPER FOR BLACK TONES

A

Hydroquinone	160 gr.	or	9 g.
Sodium sulphite (cryst.)	2 oz.		50 g.
Water, up to	20 oz.		500 c.c.

B

Caustic soda (stick or pellet)	90 gr.	or	5 g.
Potassium bromide	35 gr.		2 g.
Water, up to	20 oz.		500 c.c.

For use, mix equal parts of A and B.

With this developer the image of a properly exposed plate should appear in about ha'f a minute and development should be complete in about 2½ minutes.

ID-17. For Ilford "Warm Black" Lantern Plates

METOL-HYDROQUINONE DEVELOPER FOR WARM BLACK TONES

Metol	10 gr.	or	0·6 g.
Sodium sulphite (cryst.)	½ oz.		12·5 g.
Hydroquinone	30 gr.		1·5 g.
Sodium carbonate (cryst.)	½ oz.		12·5 g.
Potassium bromide	30 gr.		1·5 g.
Water, up to	20 oz.		500 c.c.

Development should be complete in about 1½ minutes.

Colder or warmer tones can be obtained by considerably reducing or increasing the amount of potassium bromide.

ID-29. For Ilford Gaslight Lantern Plates

METOL-HYDROQUINONE DEVELOPER

Metol	15 gr.	or	0·75 g.
Sodium sulphite (cryst.)	1 oz.		25 g.
Hydroquinone	60 gr.		3 g.
Sodium carbonate (cryst.) ..	1½ oz.		40 g.
Potassium bromide, 10 per cent. solution (pot. brom. 1 oz., water to 10 oz.	1 dr.		3 c.c.
Water, up to	20 oz.		500 c.c.

FIXING, HARDENING, ETC., FOR PLATES AND FILMS

Acid Fixing Bath

Hypo	1 lb.	or	400 g.
Potassium metabisulphite ..	1 oz.		25 g.
Water, up to	40 oz.		1000 c.c.

Ilford Acid Hypo Fixing Salts are available in tins of 4 oz., ½, 2½ and 5 lbs.

Combined Fixing and Hardening Bath (Chrome Alum)

Hypo	¾ lb.	or	300 g.
Potassium metabisulphite ..	1 oz.		25 g.
Chrome alum	½ oz.		12·5 g.
Water, up to	40 oz.		1000 c.c.

The hypo and the metabisulphite are dissolved in 20 oz. (500 c.c.) of hot water and allowed to cool. The chrome alum is then dissolved in 10 oz. (250 c.c.) of warm water and added when cool to the remainder of the bath, which is then made up to 40 oz. (1000 c.c.) with water.

Potassium Alum Hardening-Fixing Bath

Hypo	12 oz.	or	300 g.
Sodium sulphite (cryst.)	350 gr.		20 g.
Boric acid	87 gr.		5 g.
Glacial acetic acid	192 m.		10 c.c.
Potash alum (cryst.)	½ oz.		12·5 g.
Water, up to	40 oz.		1000 c.c.

Note on the preparation of acid hardening-fixing baths. The hypo should be dissolved in about one-third to one-half of the final volume of *warm* water. The sulphite and boric acid should then be added and completely dissolved. The solution, if still warm, should then be cooled to about 70°F. (21°C.) and the acetic acid diluted with four times its volume of water before being added to the hypo, sulphite, and boric acid mixture, stirring the bath during this addition. The potash alum is then dissolved in about one-

fifth of the total volume of warm water and the solution added to the rest of the ingredients, *stirring all the time*, at a temperature below 70°F. (21°C.). It is most important that these solutions be mixed at a temperature not in excess of 70°F. (21°C.). The volume is then adjusted with more water.

N.B.—It is important that the acetic acid should be diluted in a vessel free from traces of hypo, as this acid readily causes sulphurization when added to hypo in the absence of sulphite.

Hardening Before Development

When high temperatures are prevailing use Ilford Tropical Hardener. For temperatures up to 90°F. (32°C.) dilute one part of Hardener with seven parts of water. For temperatures above 90°F. (32°C.) dilute one part of Hardener with four parts of water. Allow plate or film to remain three minutes in the solution, and then pass to the developer.

Formalin Hardener

One part 40 per cent. Formaldehyde to 100 parts water. This can be used either before or after fixation, but not before development.

Hypo-eliminator

Thorough washing in water is the only perfect hypo-eliminator. Of other methods, potassium permanganate is the most satisfactory. A pink solution of the permanganate is used and the plate or film is flooded with the solution in a dish. As soon as the pink colour disappears, replace the liquid with fresh permanganate solution and continue the process until the pink colour remains and is not discharged in one minute. The plate or film after rinsing is now ready for drying.

Rapid Drying

Soak for a few minutes in industrial methylated spirit which has been diluted with one-fifth the bulk of water, and then dry in a strong current of warm air. This method is not applicable to film coated on safety (cellulose acetate) base.

INTENSIFICATION

Bleaching with Mercury and Subsequent Blackening

BLEACHING SOLUTION

Mercuric chloride (corrosive sublimate)	..100 gr.	or	6 g.
Ammonium chloride	..100 gr.		6 g.
Water, up to	.. 10 oz.		250 c.c.

The negative, *after thorough washing*, is immersed in this solution until the image is white throughout. If not perfectly free from hypo indelible stains may appear. Wash well in running water and then

blacken in one of the following solutions according to the degree of intensification desired:—

(*a*) Any plate developer.
(*b*) A solution of sodium sulphite, 1 part in 5 parts of water.
(*c*) Very dilute ammonia, 1 part ammonia sp. gr. ·880 to 100 parts of water.

Mercuric Iodide Intensifier

Mercuric iodide	45 gr.	or	2·5 g.
Sodium sulphite (cryst.)	2 oz.		50 g.
Water, up to	10 oz.		250 c.c.

Dissolve the sodium sulphite in the water and then add the mercuric iodide. To ensure permanence the negative after intensification is washed, and then developed with any plate developer for a few minutes.

Chromium Intensifier

This is simple to work, and not liable to produce stains.

BICHROMATE STOCK SOLUTION

Potassium bichromate	1 oz.	or	25 g.
Water, up to	10 oz.		250 c.c.

This solution keeps indefinitely.

BLEACHING SOLUTION A

Bichromate stock solution ..	½ oz.	or	12·5 c.c.
Hydrochloric acid (conc.) ..	5 m.		0·3 c.c.
Water, up to	5 oz.		125 c.c.

BLEACHING SOLUTION B

Bichromate stock solution	½ oz.	or	12·5 c.c.
Hydrochloric acid (conc.)	25 m.		1·5 c.c.
Water, up to	5 oz.		125 c.c.

The bleaching solution should be freshly made. Solution A gives more intensification than Solution B. Immerse the washed negative in one of these solutions until it is entirely bleached, then wash until the yellow stain is removed from the film, and develop, by daylight or after exposure to daylight, with a negative developer.

Thorough washing is necessary after intensification by any process.

REDUCTION

Ferricyanide or Farmer's Reducer

Increases contrast by reducing density in shadows much more than in highlights.

Potassium ferricyanide ..	50 gr.	or	2·5 g.
Water, up to	1 oz.		25 c.c.

A fresh plain 20 per cent. solution of hypo is used and sufficient ferricyanide solution added to colour the hypo pale yellow. The energy of the reduction is proportional to the amount of ferricyanide

present, and the process of reduction should be closely watched. Thorough washing is all that is required afterwards.

Persulphate Reducer

Decreases contrast, acting first on the dense highlights.

Ammonium persulphate	¼ oz.	or	6 g.
Water, up to	10 oz.		250 c.c.

One or two drops of sulphuric acid should be added to induce regularity of action. When reduction has gone nearly but not quite far enough, pour off and flood with a 5 per cent. solution of sodium sulphite to arrest further action. Water free from dissolved chlorides must be used.

Proportional Reducer

Acts proportionately on the densities of the negative.

A

Potassium permanganate ..	2 gr.	or	0·12 g.
Sulphuric acid (conc.)	13 m.		0·75 c.c.
Water, up to	20 oz.		500 c.c.

B

Ammonium persulphate	½ oz.	or	12·5 g.
Water, up to	20 oz.		500 c.c.

For use, mix 1 part of A with 3 parts of B.

The sulphuric acid must always be added to the water drop by drop. To add water to the acid is highly dangerous.

DEVELOPER STAIN REMOVER

Developer stain can be removed by the following solution:—

Potassium permanganate	50 gr.	or	3 g.
Common salt	¼ oz.		6·5 g.
Glacial acetic acid	1 oz.		25 c.c.
Water, up to	20 oz.		500 c.c.

The negative is immersed for ten minutes with constant rocking, rinsed, and soaked in a 5 per cent. solution of potassium metabisulphite until free from coloration. It is then re-developed with an ordinary non-staining developer.

DEVELOPERS FOR BROMIDE AND MULTIGRADE PAPERS

ID-20. Metol-Hydroquinone

Metol	15 gr.	or	0·75 g.
Sodium sulphite (cryst.)	1 oz.		25 g.
Hydroquinone	60 gr.		3 g.
Sodium carbonate (cryst.)	1½ oz.		40 g.
Potassium bromide	20 gr.		1 g.
Water, up to	20 oz.		500 c.c.

For use, dilute one part with one part of water.

Supplied in tins to make 40 oz., 2, 4, 10, and 20 gallons of working strength developer.

ID-22. Amidol Developer

Sodium sulphite (cryst.)	1 oz.	or	25 g.
Amidol	60 gr.		3 g.
Potassium bromide (10 per cent. solution)	80 m.		4 c.c.
Water, up to	20 oz.		500 c.c.

Development with the above developers should be complete in about two minutes. Afterwards, rinse and transfer to the fixing bath.

ID-21. Press Bromide Developer

Metol	60 gr.	or	3 g.
Sodium sulphite (cryst.)	4 oz.		100 g.
Hydroquinone	½ oz.		12·5 g.
Sodium carbonate (cryst.)	7 oz.		175 g.
Potassium bromide	½ oz.		12·5 g.
Water, up to	80 oz.		2000 c.c.

Use at the above strength. Development time, about one minute. Supplied in tins to make 10 gallons of working strength developer.

Acid Fixing Bath

Hypo	4 oz.	or	100 g.
Potassium metabisulphite	½ oz.		12·5 g.
Water, up to	20 oz.		500 c.c.

Ilford Acid Hypo Fixing Salts are available in tins of 4 oz., ½, 2½ and 5 lbs.

Reducer

STOCK IODINE SOLUTION

Potassium iodide	¼ oz.	or	6 g.
Iodine	20 gr.		1 g.
Water, up to	10 oz.		250 c.c.

STOCK CYANIDE SOLUTION

Potassium cyanide	40 gr.	or	2 g.
Water, up to	10 oz.		250 c.c.

N.B.—Potassium cyanide is a very strong poison and must be used with extreme care.

For use, take 1 oz. (25 c.c.) of each stock solution and make up to 20 oz. (500 c.c.) with water.

Clearing Solution

To remove yellow developer stain from bromide prints.

Alum, saturated solution	10 oz.	or	250 c.c.
Hydrochloric acid (conc.)	¼ oz.		6 c.c.

TONING BROMIDE AND MULTIGRADE PAPERS

Sulphide Toning

STOCK FERRICYANIDE SOLUTION

Potassium ferricyanide	1 oz.	or	25 g.
Potassium bromide	1 oz.		25 g.
Water, up to	10 oz.		250 c.c.

For use, take 1 oz. (25 c.c.) and make up to 10 oz. (250 c.c.) with water.

STOCK SULPHIDE SOLUTION

Sodium sulphide	½ oz.	or	12·5 g.
Water, up to	10 oz.		250 c.c.

For use, take 1 oz. (25 c.c.) and make up to 10 oz. (250 c.c.) with water.

Prints should be fully developed out. After the print is fixed and thoroughly washed, immerse in the ferricyanide solution until the image is bleached. Then wash for ten minutes and place in the sulphide solution, in which it will acquire a rich sepia colour. Finally, wash for half an hour.

Hypo-alum Toning

Prints by this process yield a purplish sepia. They are toned in a hot mixture of hypo-alum, etc., as follows:—

Hot water	80 oz.	or	2000 c.c.
Hypo	12 oz.		300 g.

Dissolve and then add a little at a time:—

Alum	2 oz.	or	50 g.

This bath requires "ripening" as, when new, it has a reducing action on any prints toned in it; this is best done by passing some waste prints through the bath or by adding silver nitrate 5 grains (0·25 g.) dissolved in a little water to which is added just sufficient strong ammonia, drop by drop, to redissolve the precipitate formed. This toning bath will last for years and will improve considerably on keeping; it should be kept up to bulk by the addition of freshly made solution.

The prints (which should be developed a little longer than for black and white prints) are toned in this bath at about 120°F. (49°C.). At this temperature prints will tone in about ten minutes. A lower temperature is not recommended as toning is unduly prolonged; higher temperatures give colder tones.

Finally, wash the prints thoroughly and swab over with a tuft of cotton wool before drying.

Rather warmer tones are obtained by adding potassium iodide 40 gr. (2 g.) to the toning bath.

Red Tones

Prints should be toned by the sulphide or hypo-alum method, and then in a gold toning bath, as follows:—

Ammonium sulphocyanide	30 gr.	or	2 g.
Gold chloride	2 gr.		0·1 g.
Water, up to	4 oz.		100 c.c.

After toning for ten minutes in this bath the desired tone should be obtained.

The prints are then refixed in 10 per cent. hypo solution for five to ten minutes and then given a good wash in running water.

Green Tones

Green tones are not generally quite so satisfactory as the other colours, but fairly good tones are obtained with the toning solutions supplied by chemical firms, such as Johnson's "Pactum" Green Toner.

Blue Tones

FERRICYANIDE SOLUTION

Potassium ferricyanide	20 gr.	or	1 g.
Sulphuric acid (conc.)	40 m.		2 c.c.
Water, up to	20 oz.		500 c.c.

Dissolve the salt in the water and then add the acid slowly.

IRON SOLUTION

Ferric ammonium citrate	20 gr.	or	1 g.
Sulphuric acid (conc.)	40 m.		2 c.c.
Water, up to	20 oz.		500 c.c.

Dissolve the salt in the water and then add the acid slowly. For use, mix the solutions in equal parts just before use.

The prints, which should be a little lighter than they are intended to be when finished, must have been thoroughly washed after fixing. They should be immersed in the toning solution until the desired tone is obtained and then washed until the yellow stain disappears from the whites. Bleaching of the blue image, which may occur on washing, may be prevented by washing in very slightly acidulated water.

Bromoil Bleacher

Copper sulphate	2 oz.	or	50 g.
Potassium bromide	2 oz.		50 g.
Potassium bichromate	50 gr.		2·5 g.
Sulphuric acid (conc.)	40 m.		2 c.c.
Water, up to	20 oz.		500 c.c.

Dilute with three or four parts of water for use. The salts must first be dissolved in the water and the acid added slowly. Bleaching should be complete in about three minutes.

DEVELOPERS FOR ILFORD PLASTIKA PAPER

ID-20. Metol-Hydroquinone

Metol	15 gr.	or	1·5 g.
Sodium sulphite (cryst.)	1 oz.		50 g.
Hydroquinone	60 gr.		6 g.
Sodium carbonate (cryst.)	1½ oz.		80 g.
Potassium bromide	20 gr.		2 g.
Water, up to	20 oz.		1000 c.c.

For use, dilute one part with one part of water.

Supplied in tins to make 40 oz., 2, 4, 10, and 20 gallons of working strength developer.

With correct exposure the image will appear in about 15–25 *seconds.*

Full detail appears in 35 to 45 seconds, after which the darker portions and shadows gradually build up with continued development, giving maximum quality within a period of 1½–2 minutes at a temperature of 65°F. (18°C.). Little further change takes place after this time, but development may be continued without any detriment up to 2½ minutes.

If the temperature is high, namely, 75°F. to 80°F. (24°C. to 27°C.), maximum development takes place in about 1 minute, and the print should be removed from the developer when full density is reached.

There is great latitude in exposure and time of development. An over-exposed print develops more rapidly and can be removed from the developer in from 35 to 45 seconds *without* loss of quality.

For those who prefer warmer tones, pleasing sepia images of consistent hue are readily obtainable with

ID-49. Plastika Warm Tone Developer

Metol	6 gr.	or	0·35 g.
Hydroquinone	54 gr.		3 g.
Chlorquinol	54 gr.		3 g.
Sodium sulphite (cryst.)	4 oz.		100 g.
Sodium carbonate (cryst.)	1¼ oz.		33 g.
Potassium bromide	15 gr.		0·9 g.
Water, to make	80 oz.		2000 c.c.

Supplied in tins to make 20 oz. and 1 gallon of working strength developer. After development, rinse and transfer to the fixing bath.

Fixing

Hypo	4 oz.	or	100 g.
Potassium metabisulphite	½ oz.		12·5 g.
Water, up to	20 oz.		500 c.c.

Allow ten minutes for thorough fixation. Use fresh solution for each batch of prints.

Washing. For two hours in running water or frequent changes.

DEVELOPERS FOR GASLIGHT PAPER

ID-36. Contact (Gaslight) Paper Developer

METOL-HYDROQUINONE DEVELOPER

Metol	56 gr.	or	3 g.
Sodium sulphite (cryst.)	4 oz.		100 g.
Hydroquinone	½ oz.		12·5 g.
Sodium carbonate (cryst.)	7½ oz.		187·5 g.
Potassium bromide ..	32 gr.		1·5 g.
Water, up to	80 oz.		2000 c.c.

Gaslight prints should be developed in about half a minute; then rinsed, fixed and washed as for bromide paper.

This developer is obtainable in packets under the name of Selo M.Q. Developer, and also in bulk quantities in tins.

ID-30. Amidol Developer

Sodium sulphite (cryst.) ..	1 oz.	or	25 g.
Amidol	60 gr.		3 gr.
Potassium bromide, 10 per cent. solution	20 m.		1 c.c.
Water, up to	20 oz.		500 c.c.

Acid Hardening and Fixing Bath for Gaslight D. & P.

Hypo	1 lb.	or	400 g.
Stock hardening solution	10 oz.		250 c.c.
Water, up to	80 oz.		2000 c.c.

STOCK HARDENING SOLUTION

Sodium sulphite (cryst.)	8 oz.	or	200 g.
Glacial acetic acid	6 oz.		150 c.c.
Potash alum (powdered)	8 oz.		200 g.
Water, up to	80 oz.		2000 c.c.

Dissolve the sulphite in 16 oz. (400 c.c.) of warm water and allow to cool. Then add the acetic acid slowly, *stirring all the time.* Dissolve the alum in 48 oz. (1200 c.c.) of hot water, allow to cool and then add to the acid sulphite mixture.

Care must be taken that all mixing be done at a temperature below 70°F. (21°C.).

DEVELOPERS FOR ILFORD CLORONA PAPER

ID-25. Metol-Hydroquinone Developer

Metol	10 gr.	or	0·5 g.
Sodium sulphite (cryst.)	½ oz.		12·5 g.
Hydroquinone	30 gr.		1·5 g.
Sodium carbonate (cryst.)	½ oz.		12·5 g.
Potassium bromide ..	30 gr.		1·5 g.
Water, up to	20 oz.		500 c.c.

Development should be complete in about 1½ minutes.

ID-23. Chlorquinol M.Q. Developer

Metol	10 gr.	or	0·5 g.
Chlorquinol (or Adurol) ..	¼ oz.		6·2 g.
Hydroquinone	¼ oz.		6·2 g.
Sodium sulphite (cryst.) ..	4 oz.		100 g.
Sodium carbonate (cryst.) ..	4 oz.		100 g.
Potassium bromide	15 gr.		0·8 g.
Water, up to	80 oz.		2000 c.c.

Development should be complete in about 1½ minutes.

One part of this developer mixed with three parts of water gives a warm black colour in about three minutes. More exposure and dilution with six parts of water gives a sepia in about the same time.

Colder or warmer tones may be obtained by considerably reducing or increasing the amount of potassium bromide.

This developer is obtainable as Ilford Clorona Developer, in packets to make 40 oz. and in tins to make 320 oz. of solution.

ID-24. Chlorquinol Hydroquinone Developer

To obtain warm black to bright red tones on Clorona Paper, the formula given below should be used, variation of tone being obtained by variation of bromide content, strength of developer, and time of development, the exposure being varied to give the desired depth of print under the development conditions in use:—

Chlorquinol (or Adurol)	60 gr.	or	3·4 g.
Hydroquinone	60 gr.		3·4 g.
Sodium sulphite (cryst.)	2½ oz.		62·5 g.
Sodium carbonate (cryst.)	2½ oz.		62·5 g.
Potassium bromide ..	6 gr.		0·3 g.
Water, up to	20 oz.		500 c.c.

Colour	Approximate Exposure	Dilution of Developer	Extra 10 per cent. Potassium Bromide Solution per 1 oz. (25 c.c.) of Stock Developer	Approximate Times of Development
	Times	*Times*		*Minutes*
1. Warm Black ...	Normal	Full strength	None	1½
2. Sepia ...	3	10	20 m. 1 c.c.	5
3. Brown Sepia...	5	15	60 m. 3 c.c.	10
4. Red Brown ...	6	25	100 m. 5 c.c.	15
5. Red	7	30	120 m. 6 c.c.	20

By normal exposure is meant the correct exposure for obtaining the best possible warm black print that is obtainable from a given negative in full strength developer.

Warm tone prints dry colder and darker than they appear when wet.

WEIGHTS AND MEASURES

BRITISH

Avoirdupois Weight

$437\frac{1}{2}$	Grains	=	1 Ounce
16	Ounces	=	1 Pound

Apothecaries Weight

20	Grains	=	1 Scruple
3	Scruples	=	1 Drachm
8	Drachms	=	1 Ounce
1	Ounce	=	480 Grains

Fluid Measure

60	Minims	=	1 Drachm
8	Drachms	=	1 Ounce
20	Ounces	=	1 Pint
2	Pints	=	1 Quart
4	Quarts	=	1 Gallon

METRIC

Linear Measure

10	Millimetres	=	1	Centimetre
100	Centimetres	=	1	Metre
1000	Metres	=	1	Kilometre

Weight

1000	Milligrammes	=	1	Gramme
1000	Grammes	=	1	Kilogramme

Fluid Measure

1000	Cubic Cm.	=	1	Litre

Equivalents

64·8	Milligrammes	=	1	Grain
28·4	Grammes	=	1	Ounce
453·6	Grammes	=	1	Pound
1	Kilogramme	=	$2\frac{1}{4}$	Pounds
3·55	c.c.	=	1	Drachm
28·4	c.c.	=	1	Ounce
568·24	c.c.	=	1	Pint
1	Litre	=	35	Oz. approx.
$4\frac{1}{2}$	Litres	=	1	Gallon

In the U.S.A. the Pint= 16 oz.; the Quart=32 oz.; and the Gallon= 128 oz.

NOTE. In this book formulæ are given in Metric and in English measures. Readers are reminded that the English fluid oz. contains only 437·5 grains and is therefore nearly 4% smaller than its American counterpart. Again, the English gallon contains 160 English fluid oz. whereas the American gallon contains 128 American or just over 133 English fluid oz.

For practical purposes the difference between the fluid oz. British and American may well be neglected, but the difference between the two gallons must be borne in mind when multiplying up from quantities of chemicals quoted in terms of fluid oz. of solution to arrive at the quantities required to make up a given solution in gallons.

In this book, too, except where otherwise stated, weights of sodium carbonate and sulphite are given for the crystal varieties. In American formulæ it is customary to quote weights for anhydrous or "dry" sodas.

Conversion details are given on page 450.

APPENDIX I

THE REVERSAL METHOD OF PROCESSING

As we have seen, the normal method of processing involves the production of a negative (in which blacks and whites are reversed) from which a positive (in which the tones increase in depth from the brightest to the darkest parts of the original subject) is produced by a separate printing operation. It is, however, possible to carry out these two operations on a single film, producing the positive image by what is called the reversal method. This technique is most frequently employed in colour work and in sub-standard cinematography.

In this process a negative image is first obtained by full development of the original latent image. This negative image is then dissolved away in a bleach bath, and then the silver halide remaining is exposed and developed to provide the required positive image. The second exposure may or may not be controlled. The second development is usually followed by fixing in a hypo bath although if the second exposure has been sufficiently great little undeveloped silver halide remains to be fixed out.

Generally speaking, ordinary negative emulsions do not reverse well, and special products for the purpose have been made available by various manufacturers, who issue detailed instructions with them.

Commonly, the first developer contains a silver halide solvent which may be ammonia, sodium thiosulphate, or ammonium sulphocyanide (thiocyanate). For the final developer, on the other hand, any normal formula may be used. By way of illustration we reproduce herewith the standard Dufaycolor processing formulæ.

Developer A

Metol..	53 gr.	or	3 g.
Sodium sulphite (cryst.)	4 oz.		100 g.
Hydroquinone ..	106 gr.		6 g.
Potassium bromide ..	48 gr.		2·75 g.
Ammonia (S.G. ·880)	210 m.		11 c.c.
Water, up to.. ..	40 oz.		1000 c.c.

Developer B

Metol..	115 gr.	or	6·5 g.
Sodium sulphite (cryst.) ..	4 oz.		100 g.
Hydroquinone	35 gr.		2 g.
Sodium carbonate (cryst.) ..	4 oz.		100 g.
Potassium bromide	48 gr.		2·75 g.
Potassium thiocyanate (pure) (Sulphocyanide)	160 gr.		9 g.
Water, up to..	40 oz.		1000 c.c.

Such developers do not keep indefinitely and where a stock solution is required B is a more suitable formula than A. Fresh developer is recommended for each film unless several are developed together.

Bleach Bath

After rinsing, preferably in distilled water, the film is bleached in the bath given herewith. During the bleaching operation, which takes about 5 minutes, it is very important to agitate the film, and this precaution is particularly necessary during the first minute of bleaching.

Potassium permanganate	40 gr.	or	2 g.
Sulphuric acid (conc.)	200 m.		10 c.c.
Water, up to..	40 oz.		1000 c.c.

Potassium permanganate dissolves slowly and the sulphuric acid must be added to the solution cautiously a few drops at a time. The presence of soluble chlorides in the bleach bath is undesirable and distilled water is recommended. After the film has been in this bath for one minute the white light may be turned on. All subsequent operations may be carried out in unscreened white light.

After bleaching, the brown stain is cleared by bathing in:

Potassium metabisulphite	1 oz.	or	25 g.
Water, up to..	40 oz.		1000 c.c.

The film is now washed for from 1–2 minutes and then exposed for about 4 minutes at 3 feet from a 100-watt lamp, emulsion side to the lamp. The second development process follows either in the used first developer or in any good M.Q. developer. Finally, the film is rinsed, fixed for 2 minutes and washed for 15 minutes.

The second exposure and the final development may be replaced by a chemical fogging treatment. Mr. Percy Harris has published precise instructions covering the application of this technique to the production of Dufaycolor transparencies, the fogging agent employed being sodium hydrosulphite (cf. *Miniature Camera Magazine*, September 1938).

Lastly, we must mention that certain products have been placed upon the market which give direct positives by straightforward development. So far, however, the use of these special products is limited to copying work.

APPENDIX II

SPECIAL PHOTOGRAPHIC EFFECTS

As we have seen in Chapter III, the behaviour and properties of light sensitive layers incorporating silver salts have provided research workers, chemists and physicists alike, with many phenomena to the explanation of which innumerable experimental and theoretical approaches have been made. During these attempts many interesting facts have emerged upon which one theory of latent image formation after another has been based and upon which many of them have crashed. The more important of these phenomena have been associated with the names of the investigators concerned in their discovery. A few of the best known are described below.

Albert-Precht Effect—reversal by destruction of the latent image with chromic acid solution. The latent image can be destroyed by bathing the exposed film or plate in a solution of chromic acid. If the original exposure is in the region of one hundred times the normal, and if, after the chromic acid treatment a second diffuse exposure is given, the result on development is a positive corresponding to the negative latent image produced by the original exposure.

Becquerel Effect. Print-out images obtained on certain non-colour-sensitive printing-out emulsions can be strengthened by subsequent exposure to yellow or red light. This effect is most readily demonstrated with silver chloride print-out emulsions.

Capstaff Effect. Non-colour-sensitive emulsions have been shown to become colour sensitive after being bathed in a solution of 2 per cent. sodium bisulphite and then washed in slightly alkaline water—the colour sensitivity extends further up the spectrum as the washing is prolonged.

Clayden Effect. A latent image produced by an exposure of short duration but of high intensity can be partly reversed by a second general exposure of the plate to diffuse light, *e.g.*, lightning or electric sparks appear light on a dark ground if the plate or film has received an exposure to a much weaker illumination afterwards.

Eberhard and Kostinsky Effects. It is found that the density of a developed image is dependent upon the actual size of the image area concerned and upon the density of adjacent areas. Further, the density of an area of image may vary from point to point even when exposure has been constant all over it. Again, the actual size of an image area may be reduced by the presence of an adjacent area so that the effective separation between the two areas is increased. All

these phenomena have their origin in the retarding effect of the products formed during the development process. Where one large area is concerned the attack of the developer is less effective at the centre of the area because the concentration of reaction products is greater there than at the edges, and enhanced edge densities are produced. Again, reaction products diffuse outwards from image areas, tending to reduce the activity of the developer and to produce lower densities in neighbouring exposed areas. In adjacent areas where there has been no exposure the fog level is reduced. The greater the agitation of the developer the less marked are these effects. On the other hand, where agitation is not employed, strongly marked "striation" effects are obtained, due to the existence of currents either of fresh developer or of reaction products. It will be clear that all these effects are closely related—where density of an image area is concerned one speaks of the Eberhard effect, and where one is concerned with image size and the separation between image areas it is referred to as the Kostinsky effect.

Herschel Effect. A latent image produced by exposure of a non-colour-sensitive plate or film can be partly destroyed by subsequent exposure to red or infra-red radiation. Plates which have received an initial fogging exposure by diffuse light may be exposed in the camera to yield direct positives. This effect has been used with success to produce infra-red spectra. It is observable both with print-out and latent images, and normal photographic desensitisers appear to act as sensitisers for it.

Sabattier Effect. If an exposed plate or film is developed, and washed, and then given a second diffuse exposure and redeveloped, certain parts of the original image may be found to be reversed. The same effect is often observed when plates or films have been developed in an unsafe light. At first the effect was believed to be due entirely to optical screening by the image produced by the first development, but although it is known that optical screening is partly responsible, it now appears that the effect can also be obtained if the second light exposure is replaced by exposure to certain chemical fogging agents. A completely satisfactory explanation is not yet possible.

Villard Effect. A latent image produced by X-rays can be partially destroyed by exposure to diffuse white light.

Russell Effects. These are fogging effects produced on development by the action of vapours given off by certain materials when placed close to the emulsion surface for a considerable time, *e.g.*, freshly cleaned zinc, essential oils and resins, printers' inks, etc. They are usually attributed to hydrogen peroxide vapour since this chemical is known to fog emulsions and also to be formed during many aerial oxidation processes.

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